SDR/SC:IAR/04/02

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

SCIENCE COUNCIL AND CGIAR SECRETARIAT

REPORT OF THE SIXTH EXTERNAL PROGRAMME AND MANAGEMENT REVIEW OF THE INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)

SCIENCE COUNCIL SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

AUGUST 2004

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24 March 2004

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Dear Drs Pinstrup-Andersen and Reifschneider,

On behalf of the Panel, I am pleased to transmit to you the Report of the Sixth External Programme and Management Review (EPMR) of the International Rice Research Institute.

We find IRRI to be a strong institute that does good science in a highly mission-oriented fashion. It is responsive to the changes in capacity, economy and livelihoods in countries where poverty and sustainability of production need to be addressed. It is also increasingly capturing the opportunities offered by rapidly evolving sciences and technologies, which are associated with a changing pattern required for productive partnerships. Additional opportunities and challenges are emerging within the CGIAR system, where IRRI can view itself as one of the leaders.

We emphasise the importance of strategy formulation and priority setting for continuous effectiveness while accommodating to changes and opportunities. We encourage IRRI to stimulate partnerships and research on rice from its unique position as the holder of an invaluable germplasm collection and associated knowledge. We advise IRRI to establish a basis for weighing its comparative advantage and chance of effectiveness in order to continuously adjust the balance in its focus to favourable and fragile rice production areas. We recommend ways of adjusting the internal organization of IRRI's research activities to better respond to its mission. We also suggest ways of helping the Board to follow best practice in fulfilling its governance role in guiding the Centre forward.

In this Year of Rice, we feel that IRRI still has an important mission and potential to have major impact towards alleviating poverty and enhancing environmental sustainability, through developing rice-related technologies that improve productivity, enhance nutrition, alleviate the plight of poor women and children and provide sustainable solutions to biotic and abiotic constraints to production.

We would like to record our thanks to the IRRI Board, management and staff, who cooperated with us in every way and provided us with all the information and facilities we required.

Finally, the Panel members and Consultant join me in expressing our appreciation for the opportunity to participate in the challenging task of conducting this Review. We hope that the Report will be useful to IRRI and its partners, as well as to the CGIAR.

Yours sincerely,

Richard Flavell
Chair,
External Review Panel

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REPORT OF THE SIXTH EXTERNAL PROGRAMME AND MANAGEMENT REVIEW OF THE INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)

Review Panel:

Richard Flavell (Chair)
John Griffith
Ann Hamblin
Martin Kropff
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Ammar Siamwalla

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March 2004

TABLE OF CONTENTS

APPENDICES

PREFACE

This is the report of the Sixth External Programme and Management Review (EPMR) Panel appointed to evaluate the research programme and management of the International Rice Research Institute (IRRI). The composition of the Review Panel and short biodata of its members are given in Appendix I. The Terms of Reference for this Review are found in Appendix II. In this EPMR less time than in previous ones was spent at the Centre and Panel members consequently did more work away from the Centre. The Guidelines for EPMRs, revised for this EPMR, are presented in Appendix III.

The EPMR Panel was guided by the general objectives of EPMRs: (a) providing the CGIAR members with an independent and rigorous assessment of the institutional health and contribution of the Centre; and (b) providing the Centre and its collaborators with assessment information that complements or validates their own evaluation effort. It reviewed IRRI's past performance, achievements, strengths and capabilities, institutional health, and vision in the light of what IRRI's role should be to contribute effectively towards serving poor households depending on rice, and sustaining the production environment in the future.

The Panel itinerary is provided in Appendix IV. The information, on which the Panel based its decisions regarding the key concerns and issues, and its assessments and conclusions, was gathered in a number of ways. These included:

- numerous documents provided by IRRI, the Science Council, and the CGIAR Secretariat, which were placed by IRRI in an EPMR Internet site and are listed in Appendix V;
- additional documentation provided to the Panel during the Initial and Main Phases, some of which are referenced in the report;
- documentation prepared for the IRRI Board meeting, observations during the meeting, and interviews of individual Board members;
- group meetings with Programme and Management staff during the visits to the Centre, followed up by individual meetings with Centre staff;
- information from the IRRI stakeholder questionnaire survey;
- discussions with government officials and IRRI stakeholders during visits in the Philippines and in Vietnam, Lao PDR and Bangladesh; and
- additional contacts with key stakeholders within and outside the CGIAR.

The Panel's point of departure was the 5th EPMR of IRRI and its key recommendations and analysis. The recommendations, IRRI's responses and the Panel's observation on progress are given in Appendix VI.

The Panel made every effort to conduct the review in an open and transparent manner. Due to the relatively short time spent at the Centre during the Main Phase, as compared to the earlier EPMR process, the Panel was not able to interact with individual staff members as much as might have been desirable during a process the outcome of which is of major interest to staff. However, the Panel members interacted with key Project and Programme staff during both visits to discuss key issues and receive clarification. During the Main Phase, daily contact was kept with the DG for discussing emerging issues and practical arrangements. Panel drafts were shared with the Centre for factual corrections.

EXECUTIVE SUMMARY

Introduction

This Review critically assesses IRRI's science and management to ensure that IRRI can continue to fulfil both its, and the CGIAR's, mission for rice. It is a forward-looking review. Also, because it takes more than ten years for the design, creation and adoption of new varieties and associated technologies, any review of an institute like IRRI needs to look ahead at least ten to fifteen years to assess the appropriateness of today's activities.

As it began this 6th EPMR, the Panel was concerned that the case for research to produce more rice and therefore the need for a $30 million-a-year Centre such as IRRI, was unclear. It has therefore re-examined this situation and concludes that, indeed, the need for continuing research to produce more rice for at least the coming decades is fully justified and the case for a role for IRRI is compelling (Chapter 1).

IRRI today is faced with dilemmas on a scale probably never experienced previously. There are the opportunities and challenges associated with the extraordinary developments in rice genomics that have developed outside the CGIAR System; the increasing use of transgenic plants; and the potential impact of intellectual property rights affecting germplasm, tools and genes. There are major developments in many other relevant areas of research, such as modelling, spatial analysis systems, and information technology, just to mention a few that have to be accommodated. Simultaneously, within the CGIAR, Centres are faced with decreases in core budgets. All these issues need to be managed within the context of the increasing competitiveness of global science and growth of Asian economies and it is certain that these issues will significantly influence the future of IRRI and its role in rice research.

The 5th EPMR already could see some of these issues emerging and concluded that IRRI needed to position itself appropriately within the emerging biotechnology environment; strengthen its spatial modelling capability; and internally, to embark on a period of stabilization – to enable a newly-appointed Director General (DG) to assume control after a period of some management turmoil and, in this context, to keep the matrix management structure in place, albeit with some fine-tuning to improve its effectiveness and efficiency.

Much has been accomplished since that Review. Under the new DG appointed in 1998, IRRI has responded effectively to the changing environment for rice. IRRI today continues to be a major player in the field of rice research: its scientific reputation is strong; it has an enviable cadre of highly qualified staff at both the national and international levels; it has first class facilities; and an excellent reputation with clients. It is financially sound, with substantial reserves.

The recommendations of the Sixth EPMR build on IRRI's re-assessed comparative advantages in the world of rice today and in the coming decade: a worldwide, politically neutral curator and disseminator of rice knowledge, a unique entry into the major rice producing areas, and a worldwide networking capability with which to advance the cause of rice as a major force in poverty alleviation which, despite IRRI's successes of the last four decades, remains its central task. The external environment is changing rapidly too: the revolution in communications, the sequencing of the rice genome and the genomics capabilities arising therefrom, and the growing scientific capabilities of other NARS, ARIs and the private sector, all of whom are ‘enablers’ to be harnessed in the cause of feeding the poor (Chapter 1).

IRRI’s role is central to this endeavour and it has successfully leveraged its relatively small investment over the years into a worldwide impact on rice through its knowledge dissemination, linkages and partnerships with a wide variety of consortia, including the NARS, and, now, with some links also to the private sector. Maintaining, strengthening and expanding these partnerships remains key to IRRI’s ability to extend its impact to alleviate poverty in the future. IRRI cannot match the financial resource inputs that others can put into rice research but it can, indeed must, take advantage of its unique comparative advantages to leverage its limited resource base and justify its role (Chapter 6).

In facing this future, IRRI goes forward on a good record of achievements over the past five years, which confirms its standing as a highly competent provider of quality and relevant solutions to rice research problems. Its track record and specific priorities for the future are now outlined.

Research for Favourable Environments

The irrigated environments produce the bulk of the rice that elevates farmer incomes and feeds the urban poor and many of the rural landless. For this reason, IRRI rightly continues to place as much emphasis on improving productivity gains from irrigated systems as on non-favourable environments. Some priorities have changed in emphasis, but IRRI remains committed to increasing the productivity of irrigated rice systems through combined breeding and natural resource management (NRM) strategies. Breeding achievements have been maintained, with over a quarter of the new varieties released through national programmes having IRRI parents. In the future, more socio-economic analyses will be needed to assess the relative impact of breeding work on grain quality traits, particularly in the high yielding hybrid varieties. IRRI will continue to work on a range of breeding strategies for combining high yield with biotic and abiotic stress resistance, in inbreds, New Plant Types (NPT) and hybrid lines.

Earlier concern for possible yield decline on very high-input, intensive irrigated production systems has been solved through thorough investigative studies and development of appropriate nutrient management systems. IRRI now believes that site-specific nutrient management coupled with integrated pest management (IPM) is the key to sustainable, high yielding production. There has been a comprehensive campaign for reducing nitrogen and agrochemical input-use in the intensive cropping regions, together with a range of water saving technologies to reduce input costs significantly. This has win-win benefits for farmers, consumers and the environment. The Irrigated Rice Research Consortium (IRRC) has grown in scope as a mechanism for research collaboration with the NARS. Its role should increase further in the future as the main delivery channel for the Programme. The Panel’s vision for Programme 2 is thus to continue to focus on overall productivity in irrigated environments, harnessing the IRRC to accelerate and enhance this process with more use of IT, biotechnology and GIS. Greater emphasis on water-saving technologies with appropriate plant varieties remains a high priority. Improvements in post-harvest rice processing can be expected to result from improvements in rice production standards in these intensive cropping regions (Chapter 3).

Research for Unfavourable Environments

IRRI focuses its resources on improvements in productivity and sustainability across the full range of rice ecosystems. It has increased its emphasis on these fragile rice production environments that comprise the rainfed lowland, flood-prone, and upland agro-ecosystems in the period under review. In spite of the enormous variability in environments, primarily with respect to agro-hydrology, a few target environments were defined and improved varieties and NRM technologies have been developed with the NARS in the CURE consortium. It was found that varieties have a wider adaptability in these environments than expected. Varieties have been adopted by farmers and the process of adoption is ongoing. As a result of several country programmes and consortia in which IRRI participates, rice productivity in countries such as Laos, Myanmar, Cambodia and portions of eastern India has increased. The Panel commends IRRI for the quality of the science and the results being obtained and supports the approach taken in the CURE programme that is based on equal partnership with the NARS.

In the future, this programme will need even more emphasis because the NARS have less capacity to work in the unfavourable systems comprising much of the rice growing area. In the rainfed lowlands, chances for improvement are higher than for flooded and non flooded upland systems. In the future, this programme will focus more on the breeding of new parental lines for NARS, and the identification of genes for tolerance for a range of abiotic and biotic stresses. These environments are also where the benefit of added attention to micronutrient enriched rice will have greatest pay-off. In these areas in particular, IRRI can have impact in improving women's plight, through targeted technologies and improved nutrition. Finally, the Programme will focus more attention on developing the NRM technologies needed for specific environments based on analyses of site-specific requirements (Chapter 4).

International Rice Genebank Collection and Functional Genomics

IRRI has continued to host and develop the International Rice Genebank Collection to a high standard and has gained accolades for its work in this area. With the opportunities that have emerged from the sequencing of the rice genome and genomics, the value of this collection held in trust for the world can now be mined and disseminated in a way that was impossible even five years ago. As IRRI moves ahead it has new opportunities to curate and disseminate the new knowledge, to do it more quickly, and to increase the collection. It has also made good progress in functional genomics and is achieving a significant position worldwide. While IRRI is not expected to compete with the many advanced genomic labs in every aspect of research, it can fulfil its vision by focusing its limited resources on those genes of high relevance to rice improvement and the Centre's breeding objectives and, collaborating externally to get techniques and powerful technologies applied to its needs. It is doing so now, and its strategies for maintaining its connectivity with the leaders in this field worldwide are sound. IRRI's policy should be to both inspire and leverage its interactions with the growing, high quality research community interested in rice genetics. If it fails, it could lose its competitive advantage (Chapter 2).

The Science Divisions

Plant Breeding, Genetics, and Biochemistry; Crop, Soil, and Water Sciences; and Entomology and Plant Pathology: the Panel was satisfied with the quality of science and the responsiveness of the Divisions to requests for inputs from the Programme groups. No changes are suggested (Chapter 6).

In reviewing the Organizational Units and Support Services/Units, the Panel was impressed with the quality and responsiveness of the work done. With specific reference to the **Social Science Division,** the Panel believes that social scientists should be involved with every major project initiative in *ex ante* cost-benefit analyses; during execution to monitor and weigh the probabilities of its success; and *ex post* to evaluate its impact on the well-being of affected households. This expansion in its role implies an increased social science capability within IRRI (Chapter 5).

Training and Knowledge Dissemination

The Panel believes that training and knowledge delivery in IRRI should not be treated as just another project. Its activities already spread across the full extent of the research projects, which have constant interaction with its functions in providing information to the Rice Knowledge Bank and its contributions to training modules. The Panel envisages an increase in the prominence of the whole of the knowledge delivery activities in IRRI in the future. IRRI's experience and lead in packaging knowledge and delivering it through the Rice Knowledge Bank, for example, can provide a model for other initiatives in the CGIAR. The 'Training' Centre will be better viewed as a cross-institute programme that contributes to the delivery of the research output.

Both of the observations pertaining to social science work and to training imply that Programme 4 as it now stands would cease to exist (Chapter 5).

Partnerships, Consortia and Networks

One of the key factors in IRRI's successes over the years has been its strong working relationships with the agricultural agencies of rice-growing countries in Asia and the excellent tradition of collaborative scientific research with many leading Agricultural Research Institutes around the world.

IRRI has bilateral arrangements with sixteen rice growing countries in Asia, with offices in ten of these to support the research and training staff located in those countries. Without this very large set of partnership arrangements, IRRI would cease to function in its present capacity. The range of networking activities is very wide, and provides an effective mechanism through which IRRI can draw adequately on the world's knowledge of rice science, listen and respond appropriately to clients and deliver targeted research results to where they are most needed. The Panel firmly believes that these partnerships have a vital role in the future – just as they do today, and recommends that rice dependent countries make every effort to maintain them through adequate resourcing of their associated consortia and networks.

IRRI is the initiator or a member of over ten active consortia and networks. Over the past five years, the IRRI-NARS interactions have strengthened considerably through the expanded role of IRRC and CURE. The Consortia have evolved into meaningful research partnerships where experiments are conducted at joint on-farm sites and regional priorities are identified and acted upon together. The Panel suggests that the role of these Consortia be expanded in the future to become the principal delivery vehicles of IRRI's products, information and knowledge training for rice growing countries. This is particularly important in the case of INGER which has lost external funding in the past.

The Panel cannot over-emphasize the importance of maintaining and building effective partner relationships in fulfilling IRRI's role. All at IRRI fully appreciate this, but are faced with a wide range of country and donor priorities. The Panel noted that this inevitably leads to some degree of short-term *ad hoc* solutions to the distribution of resources and research effort across countries. Elevating the role of Consortia both within IRRI and externally to 'flagship' status and presence should reassure donors of the continuing value and relevance of IRRI's work.

Host Country Relations

The Panel gained evidence from senior government officers that IRRI's presence is still welcomed in the Philippines and IRRI's contribution is recognized as very significant. IRRI's relations with PhilRice are good, and IRRI values the opportunity to have PhilRice as a partner for bringing advanced germplasm into commerce, including hybrid rice.

IRRI is sited on land owned by the University of the Philippines. It renegotiated its lease in 2000 for another twenty-five years. Relations with the University are good, although more interactions between University faculty and IRRI staff would be welcomed.

One concern is proposed changes to legislation in the Philippines that would remove IRRI's diplomatic immunity with regard to labour. IRRI fully complies with Philippine labour laws consistent with its diplomatic status. However, this proposed legislation has not prospered to date in both Houses of Philippines Congress.

IRRI in Africa?

The Panel, as well as IRRI's Board, is asking whether and how it should extend its work into Africa. The case for going into Africa rests almost entirely on the number of poor there, which is second only to South Asia among the major regions of the world. But is rice research from IRRI the appropriate means to tackle that problem, given the fact that rice is merely one of the many food crops grown and consumed in Africa? Besides, the rice that is grown, is grown mostly in upland conditions in fields with mixed farming. IRRI's work in areas with similar ecosystems in Asia has not been productive. There are irrigated areas in parts of West Africa, and rainfed lowland paddies in Madagascar where IRRI could make a useful contribution, but added together, these produce somewhat less than 5 million tons currently, a little above Nepal's production.

The Panel suggests that IRRI should carefully examine the cost-effectiveness of any expansion into Africa. Should it decide to go ahead, it should do so in tandem with partners, for they are needed to work in the peculiarly difficult agronomic conditions of that continent. For West Africa, IRRI cannot proceed without WARDA with whom relationships in the past have, on occasions, been somewhat strained. The Panel suggests that, as a starting point, potential partners be invited to Los Baños where, in light of what IRRI has to offer, all potential partners can develop a coordinated approach to extending rice research in the continent that builds on the respective competencies of each partner, and seeks those synergistic relationships that donors will expect.

Organization

The Panel has concluded that IRRI would benefit from organizing its principal scientific thrusts through three flagship Programmes. Two would cover the outputs targeted under Favourable and Unfavourable environments respectively. Each would be strengthened and given more visibility by a Programme Leader with augmented responsibilities for implementation, who will act a spokesperson for the Programme's vision and objectives.

The third flagship Programme would both underpin the above Programmes and encompass the IRGC, with its essential external links to the global rice genomics and genetics community. The current 4th Programme would be discontinued and some of its social sciences incorporated into other Programmes. Training and knowledge dissemination would assume a high profile status as a separate entity but linked to all other Programmes (Chapter 8).

Quality Assurance

The Panel notes that, throughout the period under review, IRRI has developed sound systems for assuring the continued quality of its work. IRRI has an enviable record of delivering effective solutions to problems. A detailed performance evaluation system has been developed to evaluate the performance of IRS annually. Senior scientists in all scientific divisions publish in international refereed journals at a rate comparable with good academic institutions while functioning in a setting where they combine scientific activities with applied research programmes with NARS. Many of these scientists have received tokens of recognition in the scientific environment. The Panel rated the scientific quality of the research in the different programmes as very good. This is partly due to the high quality services that scientists can rely upon within the Institute. The Panel believes that IRRI, and the next EPMR, would benefit from greater use of CCERs on key research topics and on selected management topics to assure the Board of IRRI's continued effectiveness and efficiency (Chapter 6). The Panel believes that constant vigilance on quality assurance mechanisms is particularly important in all aspects of germplasm exchange (Chapter 8).

Matrix Management

IRRI has adopted the matrix management (MM) process for the four major Programmes comprising 12 interconnected Projects with associated support across the scientific disciplines, service units and the Training Centre. Though complex, this structure has worked well and has contributed to the excellent science that typifies IRRI today. IRRI has modified the process to avoid problems typically associated with the concept and also to more closely align tasks – and the responsibilities for carrying out those tasks – with the individuals who can be held solely accountable for results. No significant changes in the MM processes are proposed (Chapter 7).

Planning and Control

IRRI's planning processes for identifying and prioritizing all the activities that comprise its overall work programme are comprehensive. Once the Board has approved a strategic plan, a rolling Medium Term Plan (MTP) is prepared that outlines, by project, the individual tasks, resource requirements, intermediate- and end-products, time deadlines and responsibilities for achieving results. Projects are controlled by comparing expenditures against approved budgets, and qualitatively by comparing progress in reaching project/task milestones as outlined in the MTP. The Panel considers that improvements in presentation and clarification of goals would make the MTP a more useful document.

Preparing this complex planning document is time consuming. The Panel puts special emphasis on the planning process, not only to describe what IRRI will do, but also to optimize its comparative advantage and fitness to compete in a fastly changing environment. Staff are involved in the planning process – in setting out the range of projects and tasks that constitute a possible work programme. What is less well understood by the Panel is the critical next step in the planning process – how priorities are actually established and resources ultimately allocated between competing claims on limited resources. The Panel notes that staff involvement in all aspects of the planning and priority setting process will enhance 'ownership' of the end results of the process.

The Panel suggests that in the planning process, all projects should have clear end user goals and assessments of the probability of their being realized and adopted (Chapter 7).

Governance and Management

In reviewing the work of the Board of Trustees and Management, the Panel notes the newly emerging challenges facing IRRI in the years ahead due to changing funding patterns; changing relationships with clients; increased scrutiny from donors; and increasing liability exposure of Trustees to the results of decisions taken by the Board. As the 'bar' in governance performance is being raised, IRRI's Board will need to match its *modus operandi* with these new demands including: taking a more substantive role in developing the strategic plans for the institute and for monitoring progress against the approved plan; receiving more timely information about the conduct of IRRI's affairs; and making greater efforts to recruit Trustees whose competencies match the Institute's emerging requirements across a wide variety of disciplines. The Board should also adopt more comprehensive Investment Guidelines that match the increasing size and complexity of the Centre's investment portfolio. In reviewing the processes and systems used in managing its own operations, and the independent auditing of its activities, the Panel concludes that donors can be assured that funds given to IRRI are being appropriately managed (Chapter 7).

The Panel commends IRRI for its progress in dealing with IPR issues. Its Board approved policies on this topic and on the interaction with the private sector are well founded. They uphold the principles of the need to produce international goods available to all, but also provide for opportunities to negotiate licences to use technology that could be of enormous benefit. There is now the on-going challenge to get the principles of good management of IP understood and practised in the organization, where appropriate. IRRI is also now charting a careful, but sound, way forward on developing and evaluating transgenic plants, to be deployed into agriculture by the NARS. IRRI should continue to keep a careful watch with its partners on developments in this important area. The Panel emphasizes that IRRI do nothing that could conceivably lead to the contamination of its IRGC stocks with transgenic seed.

IRRI and the CGIAR System

There are natural tensions between the many components of the CGIAR system. The CGIAR has no legal identity, and all its donors have a seat at the table – making it rather impotent as a decision making body.

The CGIAR Centres are legally autonomous and each Centre's Board has the authority, and ultimate responsibility, for determining and carrying out its programmes and policies. However, the CGIAR has recently established a Science Council that is envisaged to have some jurisdiction over the science at the Centres. Further, as seen by the strong growth in special programme funding at the expense of core funding, donors obviously have strong wishes for what Centres should be doing and there is little commonality between donors' expectations. In addition, last year, the CGIAR introduced Challenge Programmes to which it is expected that Centres will bid for, and win, funds. A significant portion of these funds come from the previously expected budgets of the Centres. Whatever their merits, these Challenge Programmes therefore distort the programmes of the Centres away from previously accepted, and presumably high priority goals. Centre Trustees were not consulted about these changes.

All these issues create difficulties for all members of the CGIAR family. They create particular difficulties for the Management and Boards of the Centres. These difficulties need to be minimized or resolved, otherwise they sap energy from the science and purpose of the Centres, create cost inefficiencies and, especially, undermine the aspirations of talented people. IRRI is no exception and the Panel noted many issues stemming from these structural tensions.

It is not the place for an EPMR to solve these tensions involving multiple layers of leadership. The Panel strongly urges that they be addressed, however, because of their obviously deleterious effects on the system, including IRRI, and the potential for decreasing the System's impact on poverty alleviation.

IRRI's Role in the Future

IRRI is uniquely positioned in a field of science that today is itself full of new and exciting opportunities like never before. IRRI will play an important role in rice research in the future. It has a set of unique core competencies in terms of being an apolitical, neutral curator of the rice germplasm collection and knowledge base; in having a worldwide networking capability second to none; and in knowledge dissemination. Sustaining and utilizing this set of competencies for the next 5-15 years in the optimum manner will be a challenge, but the Panel believes IRRI is capable of, and indeed well on the way towards maintaining its unique contribution to alleviating poverty.

The Panel is convinced there is a need in Asia for IRRI, given this unique set of core competencies. The Panel envisages an IRRI that is clearly recognized externally and internally as being a leading rice-based international institute delivering knowledge and tested products and concepts that demonstrably contribute to alleviating poverty and enhancing environmental sustainability. It does this by inspiring and harnessing the world's research community, leveraging it for the needs of the poor. It links interdisciplinary sciences that reflect the increasing complexity of rice production systems with those best equipped to deploy them and is therefore neither an upstream nor a downstream organization.

KEY RECOMMENDATIONS

Chapter 2

1. The Panel **recommends** that IRRI stimulate the global community to establish gene-trait linkages in carefully selected germplasm in a targeted way, as rapidly as possible, for purposes of plant improvement, making results available to all. IRRI should report to the Board of Trustees by April 2005 on its progress in implementing this initiative with its partners.

Chapter 3

2. The Panel **recommends** that IRRI link the work currently carried out in Project 5 with the challenge of achieving higher yields in the most intensive production systems in the context of diminishing water supplies. Further, IRRI should extend its modelling and GIS research to optimize water-saving technologies at the irrigation scheme level to provide options for water allocation.

Chapter 4

3. The Panel **recommends** that IRRI include the results of *ex ante* impact studies in unfavourable environments in its priority setting exercises. The existing evidence indicates that less emphasis should be placed on uplands with low production potential and more emphasis is needed on rice-based cropping systems along the toposequence and favourable non-flooded rice systems.

Chapter 5

4. The Panel **recommends** that activities on 'Constraints to adoption of improved rice technologies assessed' in Project 10 and the entire Project 11 be transferred to Programmes 2 and 3, while the rest of the activities in Project 10 be done in a new stand-alone Project, with Programme 4 being dissolved.

Chapter 6

5. The Panel **recommends** that IRRI establish a forum of rice growing countries with the purpose of financing and revitalizing INGER.

6. The Panel **recommends** that IRRI commission a study, based on the vision of IRRI's role in 5-15 years, to assess the relative merits of the current model comprising some outreach activities, but with the majority of scientists in headquarters, with a model which has more outreach research staff in all those rice producing countries where close proximity and visible presence are deemed necessary.

Chapter 7

7. The Panel **recommends** that, annually, the Nominating Committee develop a List of Trustee Competencies required by IRRI over the next 5 years and, on approval by the Board, develop its list of potential candidates accordingly. This List should also be a key input in the Board's decision as to whether a second term should be offered to current Trustees up for re-election. Automatic second term election, even where there are no adverse circumstances suggesting otherwise, should not be the norm.

8. The Panel **recommends** that IRRI provide all members of the Finance and Audit Committee with:

   i. a monthly Cash Flow forecast for the ensuing 6 months;
   ii. monthly income and expenditure statements (with actual-vs.-budget comparisons and commentary);
   iii. quarterly reports on project costs and revenues – highlighting those where cost under/over runs exceed 10% and articulating what management is doing to resolve the issues; and
   iv. monthly reports on investment income compared to budgeted income.

   All Board members should receive this same information on a quarterly basis, and all these reports should be available to Board members within 20 days of the end of the reporting period.

9. The Panel **recommends** that IRRI develop updated Investment Portfolio Guidelines that cover the broad spectrum of portfolio management guidelines typically addressed, including maturities; types of instruments; risk assessment, risk management and reporting; benchmarking arrangements; currency hedging arrangements; and the risk and portfolio reporting procedures for the FAC and the Board, for the External and Internal auditors, and for Management.

Chapter 8

10. The Panel **recommends** that Programmes 2 and 3 become the flagships of IRRI's research effort, with strong and articulate Leaders, who should prioritize and implement integrated research within their assigned ecosystems. They will be IRRI's representatives in the Programmes' research consortia and will be the spokespersons for their respective Programmes. The Leaders should have the following tasks:

    (i) When setting priorities they should evaluate alternative approaches to alleviating the poverty problems in their ecosystems, and recommend changes to project structure as needed.

    (ii) In implementing the research they should control the GOC and FTE inputs, and thus may negotiate for the human resources from all the Divisions as needed.

    (iii) At particular milestones during or at the close of their research, they should sponsor studies of the impact of their work.

CHAPTER 1 – CHALLENGES FOR RICE RESEARCH

1.1 Introduction

This Review seeks to assess critically most aspects of science and management that the Panel and the Institute Management believe are important for IRRI to continue to fulfil its mission and also that of the CGIAR on rice. It is a forward looking review based on the belief that, because it takes more than 10 years for the design, creation and adoption of new varieties and associated technologies, any review of an institute like IRRI needs to look ahead at least 15 years to assess the appropriateness of today's activities.

IRRI has a global responsibility for rice under the CGIAR umbrella. This is an extraordinary responsibility given that 44% of the world's population has rice as its staple food and 65% of the world's poor rely on rice for survival. The CGIAR mission has been adopted by IRRI, and reformulated to IRRI's particular responsibilities as stated in its mission:

> *to improve the well-being of present and future generations of rice farmers and consumers, particularly those with low incomes.*

The Centre today consists of some 900 staff, of whom 105 are international staff and 784 are nationally recruited. These numbers are much reduced from those of 1997 when IRRI had 1,680 staff, which became further reduced to 1,115 in 1998, at the time of the last EPMR. This reflects the reducing resources at IRRI's disposal over the preceding decade. Today's resources are distributed with approximately 52% to core and 48% to special projects.

These reductions need to be evaluated against the total of the CGIAR over the past decade and set against the background whereby, over the past 5 years, there has been an unparalleled increase in investment in rice research worldwide in developed and developing countries, especially China. They have occurred at the very time that rice science has been progressing as never before and others have been investing more to create and drive the new science.

IRRI's outputs have been substantial in previous decades. Early emphasis was placed on plant breeding and the release of improved varieties. The early impact was extraordinary, giving rise to the so called Green Revolution. Over the years, IRRI's strategy has become more complex, as all have recognized that providing new germplasm can meet only some of the goals. The environments that can benefit from Green Revolution high yielding rice varieties are limited and therefore different products need to be generated and can only be devised successfully by being selected from materials already adapted to these environments, evaluated across many sites and deployed in more complex farming systems. Over the past few years, IRRI has increasingly recognized the growing competencies of some of the NARS, its partners, and today does not aim to produce finished varieties for them but instead mostly seeks to produce germplasm that they can develop.

IRRI's mandate is to deliver outputs that are public goods. It clearly seeks to retain their role in spite of the many challenges that have emerged in the past 5 years. These include threats to the unrestricted movement of germplasm and restrictions on the use of genes and other biotechnology reagents due to the filing of patents. These changes are serious challenges to the strategies of the CGIAR and IRRI in particular.

IRRI today is faced with dilemmas on a scale probably never experienced previously. These greatly complicate planning for the future and the priority setting exercises. They include the complexities of poverty in Asia and how IRRI can contribute to its alleviation most effectively over the coming decades. There are the opportunities and challenges associated with the extraordinary development in rice genomics, developed outside the CGIAR System, the use of transgenic plants and intellectual property rights affecting germplasm, tools and genes. There are parallel developments in many other relevant areas of research, such as modelling, spatial analysis systems, and information technology, just to mention a few. Then there are new developments in the CGIAR and decreasing core budgets. All these need to be managed against the increasing competitiveness of global science. The magnitude of these issues is such that we now elaborate on some of those newer external factors that will influence the future of IRRI and its role in rice research. This serves as a background to evaluate how IRRI should evolve to ensure its cost-effectiveness in the coming decades.

1.2 Will There Be Enough Rice in the Next Twenty Years?

For the last fifteen years, a question has been persistently nagging IRRI and its donors: does it have any real role to play in the future that would justify investment at the rate of 30 million dollars or so every year? There is no doubt that it has been a very successful and productive organization throughout its life, and if past history is to be the sole guide to future prospects, there is no question that IRRI should continue to enjoy the support of its stakeholders.

But the question refuses to go away, notwithstanding IRRI's insistence that past gains must not be merely enjoyed, but also defended, and the main means to do so is to invest in yet more research. Fears of environmental degradation and long-term decline in potential yields have led IRRI to conduct some very fundamental research, even though the basic thesis has now been questioned, partly by work done by IRRI staff itself. Nonetheless, research stimulated by the concern for the sustainability of productivity within irrigated areas has led to some useful recommendations, for example for changes in cultivation practices in the rice-wheat areas of South Asia. The ever-present threat posed by insects and pathogens has been tackled in environmentally undisruptive ways. Meanwhile, the main thrust that has established IRRI's reputation, namely its genetics and plant breeding, has continued on its highly successful path, now enhanced by new biotechnological tools.

Both as a result of IRRI's work as well as of other developments, rice has kept pouring out of Asian farms, bringing rice prices down continuously, until they have touched historic lows in real dollar terms. Projections of future rice supply-demand balances and therefore of future price trends undertaken by IFPRI economists indicate that the world can look forward to further price declines, thanks in part to slowing population growth and in part to continued diffusion of modern varieties to newer areas.[1] The baseline projection indicates that real rice prices will fall by a further 22% between 1997 and 2025. Indeed, in some

[1] Sombilla, M. et al. 2002: A long-term outlook for rice supply and demand balances in South, Southeast and East Asia, *In* M.Sombilla, M. Hossain and B.Hardy (eds.), 2002: Developments in the Rice Economy. Los Baños, IRRI.

countries, high economic growth has led to a slowing down of consumption growth and to a decline in per capita consumption of rice. The Malthusian fear of population growth outstripping supply potential that led some far-sighted individuals to establish IRRI in 1960 is, it seems, no longer operative.

An important caveat has to be inserted at this point. The decline in dollar prices has relevance for international rice traders, but for few other people, and decidedly not for most rice consumers and producers in Asia. To get at that one has to look at the domestic prices. Figures 1.1 and 1.2 show data of real wholesale rice prices in domestic currencies for selected Asian countries going back to 1966, as well as of the real dollar prices of internationally traded rice. While these domestic prices have undoubtedly dropped from the high levels of the mid-1960s, the decline seemed to have stopped after about 1975, unlike the decline in real world prices (in dollars) which continued after 1975. The main reasons were both a depreciation of the exchange rates, and the increasingly protective trade regime for rice, as some of the importing countries achieved self-sufficiency.

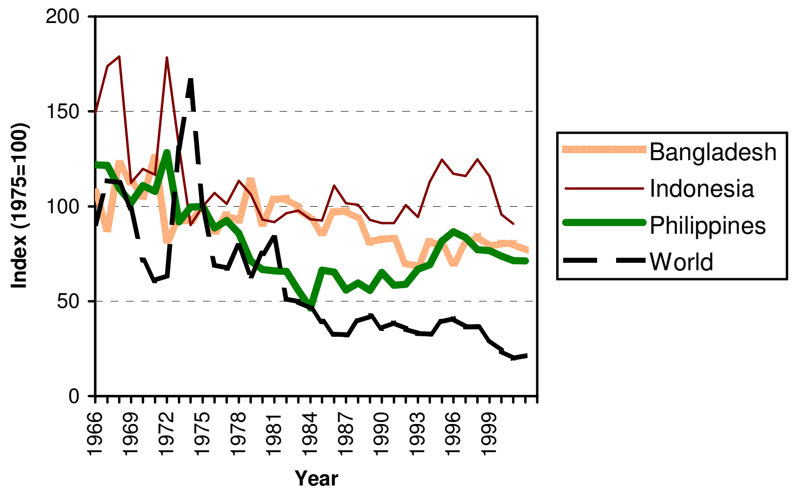
Furthermore, the forecast of a continued fall in the dollar price for rice in the baseline projection is based on the assumption that "governments make no major changes in their agricultural and economic policies and investments if population grows at the rate given in the United Nations medium projections". As far as investments are concerned, two important items are worth bearing in mind: investments in research, both at the national level and at IRRI; and just as importantly, investments in irrigation which in the last two decades have sunk to much lower levels relative to the level reached in the 1970s.[2] This lower level of irrigation investment is also projected into the future.

Without the investment in research, the yield growth that Asian countries have been enjoying over the last few decades can no longer be sustained. The projections indicate that future rice prices are strongly influenced by assumptions about the future trend in yield growth. Thus if the growth rate of yield between 1997 and 2025 is half that of the baseline projection – 0.5% instead of 1.0%, the latter itself half that experienced between 1967 and 2000 – then rice prices will jump by roughly 50% from their levels in 1997.

Nonetheless, the baseline assumption of future rice investments being able to maintain a yield growth of 1% per year seems modest enough, and recognizes the diminishing returns that are inevitable after the stellar performance of the last third of the 20th century. If, on the other hand, there are to be new breakthroughs, whether with hybrid rice or with the new plant type, and yield growth were to accelerate by about 20% in developed and 40% in developing countries over the baseline growth rates, the effect in the rice markets will be no less spectacular, with rice prices in 2025 dropping by almost 60% from their levels in 1997.

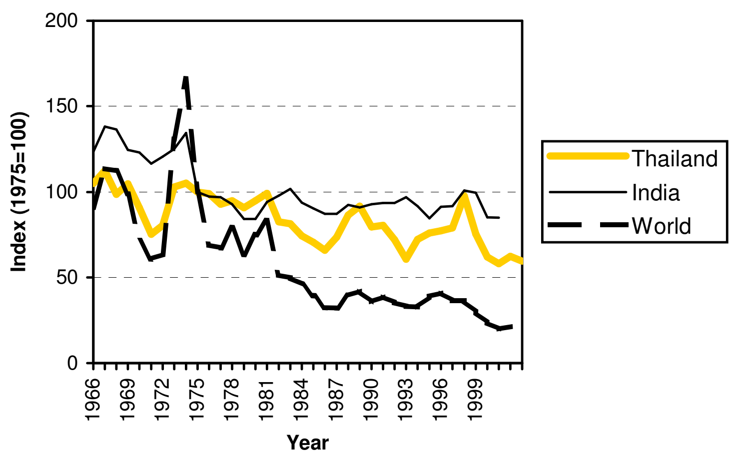
[2] To some extent, reduced public investment in irrigation which is fairly well documented is being compensated by private investment in tubewells, the size of which is not known.

Figure 1.1 - Trend in Real Price of Rice, Major Importing Countries in Asia, 1966-2003



Note: Wholesale price of rice deflated by general price index.
Source: 1966-1998: World Rice Statistics database.
1998-2003: Websites of national statistical organizations.

Figure 1.2 - Trend in Real Price of Rice, Major Exporting Countries in Asia, 1966-2003



Note: Wholesale price of rice deflated by general price index.
Source: 1966-1998: World Rice Statistics database.
1998-2003: Websites of national statistical organizations.

These projections indicate a lower bound to yield growths at a level somewhat less than 1% that must be achieved in the coming decades for rice prices not to rise substantially, a figure that appears to be attainable. There is therefore less urgency to produce a bigger pile of rice merely to keep up with demand; less urgency, but not complacency. Even with the slackening of demand due to lower population growth rate and smaller income elasticity, the baseline projection from IFPRI indicates that the world would still need an extra 132 million tons of milled rice between now and 2025. Continued investments in research still need to be done, both at IRRI and in the national agricultural research systems.

Another reason not to be complacent is the water situation faced by the world today. Increasingly, the world is waking up to the quite strong possibility that water is becoming more scarce, none more so than in northern China. The CGIAR has set up *Water for Food* as one of the Challenge Programmes for the System, in which IRRI is participating. In approaching this problem, IRRI needs to bear in mind that rice is among the most water-intensive crops grown. As such, it is the least efficient converter of water into calories, and it probably would make more sense for the world to obtain its calories from other cereals, such as wheat. Given that Asians will still want to consume and produce rice, IRRI must find a better solution for them. It turns out that IRRI has, for well over a decade, undertaken research to increase water productivity in rice production, and has some promising leads on how to do so successfully in the field.

1.3 Rice Research and Poverty

The bigger pile of rice that has come out of Asian farms has naturally had an impact on the national economies, which have led in a few cases (e.g. Indonesia, at least before 1997, Vietnam after 1989) to tremendous growth in incomes of the farmers themselves. This by itself has led to a reduction of poverty, even though most of the farmers who benefited from the new technology worked on well-watered land, and therefore could not be counted among the poorest of the poor people in rural Asia. Nonetheless, there is no question that the standard of living of these farmers has improved from a level which was quite modest to something that approaches prosperity.[3] To be sure, income inequality has increased within such farming communities. That is partly due to the in-migration of people coming in to share in the prosperity of the favourable areas from parts that were even worse off, and to the growth of rural non-farm activities, which generate income for households with a more skewed distribution than farm income.

But the contribution of the bigger pile of rice in reducing poverty did not lie in the income it generated for the beneficiary farmers; much more importantly, it helped a great number of rice-deficit households in both urban and rural areas. Most poor people are drawn from these ranks. They benefited from the new technology in two ways: they could purchase their rice much more cheaply, and, for those in rural areas, they could obtain more employment because of the increased labour demand that arose from the intensification of production.

A third pathway out of poverty, arguably the most important, is through the acceleration of economic growth made possible by the relaxing of the food constraint. The story of Asia's emergence as an industrial powerhouse is now well known, but this would not have been possible without the prerequisite agricultural growth, to which the Green Revolution contributed a great deal. It is the higher economic growth that is responsible for much of the reduction in poverty that has occurred.

Tremendous as these achievements may have been, they mostly lie in the past. Farmers who benefited directly from the new technology, mostly living in favourable environments, could no longer be counted among the poor. Most of the promising technology

[3] See for example Hayami, Y. and M. Kikuchi, 1999: A rice village saga: three decades of Green Revolution in the Philippines. Los Baños, IRRI.

in IRRI's and the national research systems' pipeline is still geared to this group. Yet the new technology has also left behind in its wake a large number of rice farmers mired in poverty, some of whom have even seen their conditions worsened by the new technology, which lowered the price of their rice without giving them the higher productivity.

It is true that the more favourable of these unfavourable areas, such as Eastern India, have benefited from increasing productivity during the last decade and a half. Increased use of groundwater and, in the case of deep-flooded areas, a shift of the cropping calendar away from wet to dry season, has allowed farmers to reap the benefits of the modern varieties. Even without these changes in the water regime, some of the better rainfed areas find that they can profitably use the modern varieties. This indicates that the momentum of productivity growth from the Green Revolution has not died down yet.

For the poor rice consumers, a decline in rice prices will undoubtedly continue to benefit them, but the impact will be reduced relative to what it was in the last decades of the 20th century, as rice occupies less and less of their budgets. Having said that, it is necessary to point out that the poorest 40% of rural households in Bangladesh still spend as much as 35% of their budgets on rice, and in Vietnam, the bottom quintile of households in Vietnam spends 47%.[4]

The employment effect of the new technology is also going to be less, as farms are increasingly mechanizing their operations. Indeed, it is facing a dilemma here. In the past, IRRI has been somewhat reluctant to introduce labour saving technologies, because of the adverse employment effects. But in countries where wages are rising because of developments outside the rice sector, there is now also a need to ensure that rice farming remains viable, and labour saving technologies will have to be introduced.

Finally, lower food prices will still feature in accelerating economic growth, particularly in countries that are in their earlier stages of industrialization, e.g. Bangladesh, Vietnam, and Sri Lanka. But for those countries that are somewhat beyond that stage, the price of rice is no longer a central issue.

One final observation on the issue of poverty, IRRI has always conducted part of its research with the aim of benefiting producers in less favourable environments. This was done, even though hard-headed calculations showed that it would not have been worthwhile, as has indeed turned out to be the case. Results from the investments on upland ecosystem research have been meagre. Still no research yield has come through. The question that now needs to be addressed is whether rice research could cost-effectively contribute to poverty reduction in these unfavourable areas and whether IRRI should expand its budgets for programmes and projects catering to them.

The term 'unfavourable' actually ranges from the more favourable rainfed environments, which have a fairly high water table allowing for the use of groundwater resources and therefore have great potential, all the way to the recalcitrant uplands. The criticism has been levelled that, as long as IRRI works exclusively on a single crop, it cannot

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[4] Figures on Bangladesh are compiled by the Social Sciences Division, IRRI from the Household and Expenditure Survey 2000, conducted by the Bangladesh Bureau of Statistics. Figures on Vietnam are from Hoanh, C.T. et al. 2002: Rice Supply and Demand Scenarios for Vietnam. In: M.Sombilla, Mahabub Hossain and B.Hardy (eds.), 2002: Developments in the Rice Economy. Los Baños, IRRI.

do anything useful in these upland areas, and in response, IRRI has begun to move into 'rice-based systems'.

A key issue for this review is therefore how much resource IRRI should put into these unfavourable areas as a whole vis-à-vis the irrigated areas and, within the broadly defined unfavourable areas, what strategies are worth following.

1.4 Rice in Asia and Africa

Of all the CGIAR Centres, IRRI has the most compact mandate because it works on a single commodity, and 90% of it is grown in Monsoon Asia. As long as there is the perception that more of the world's poor people are in Asia than anywhere else, IRRI can justify its working almost exclusively there. Even though that perception reflected the truth accurately and remains true to this day, donors' perception seems to have shifted for they now place a greater priority on the poor in Africa.[5]

The problem in Africa is complex, not only because of the nature of the problems to be tackled, but because WARDA, the CGIAR Centre charged with rice research in West Africa, is now in some difficulties for reasons beyond its control. IRRI nevertheless is drawn towards working in Africa. Before deciding to do so, IRRI needs to address the following question: can it spare the limited resources that would need to be diverted from Asia to Africa – and by this is meant not just the funding, which IRRI should be able to obtain from the donors – but also its limited core of competencies? In short, does it have the comparative advantage to convert the extra funding into good results on the ground? In the review that follows, we shall bear in mind these questions.

1.5 IRRI and National Research Systems

In its mandate to bring better technology to rice farmers, IRRI works in close collaboration with its counterpart in the national systems. One of the better side-effects of the Green Revolution was to convince many Asian governments that investment in agriculture (particularly agricultural research) pays. Surprisingly, except in the Philippines until about 1990, investments made by IRRI did not crowd out investments in the national systems. Since the emergence of IR8, many large- and medium-sized Asian countries have expanded their agricultural research systems. Over time, many (although not all) of these research systems have acquired capabilities that enabled them to interact profitably with IRRI, in some cases on an equal basis. As a result, the work done at IRRI began to shift to encompass more upstream research. Thus in breeding, IRRI now no longer releases new varieties to be directly used in farmers' fields. Release of such varieties is now done by the national systems, based on lineages that have IRRI's varieties among them. IRRI's work is confined to pre-breeding lines that are potentially useful to the national systems, leaving to the latter the task of adapting the varieties to cope with the environments or the quality demands specific to their countries. Similarly, some of the training that used to be done by IRRI has been turned over to the stronger national systems.

In their development, IRRI has served as a beacon and a role model. It has also been a mentor. IRRI has provided training to many scientists now in senior positions in the national

[5] Latin America raises no issue for resolution, as CIAT has the mandate to be the CGIAR Centre that works on rice in Latin America, and its relationship with IRRI as the global germplasm centre poses no problem.

systems. Thus, these national systems are not merely clients of IRRI, but feel themselves to be its stakeholders.

Not to be overlooked, however, are those countries that for a variety of reasons, such as wars or the small size of the countries, do not yet have a research system that can deliver the kind of product that is taken for granted in the medium and large countries discussed above. These countries do require considerable assistance from IRRI, which it tries to provide to the extent that bilateral special project funding permits. One country that has obtained such help that is now well on the way to autonomous development of its research system is Vietnam.

The emergence of a large number of peer research systems in Asia will thus feature in our discussion of the direction towards which IRRI is to move. Alongside this change is the emergence of the private sector, mostly in developed countries, as active investors and producers in the field of agricultural research. This raises its own complex set of issues.

1.6 Rice Genomics and Plant Breeding

It is safe to believe that selection, evaluation and adoption of new varieties will continue to be a strong driver to reduce poverty either directly or indirectly. Thus this component of the strategy of the CGIAR since its inception will remain intact for some decades to come. However, the process of plant breeding that drives the availability of new varieties is beginning to change radically and the rate of change will accelerate over the next two decades. The new situation arises from the technical developments called ‘genomics’. Genomics seeks to describe every gene in a species, provide rapid ways to survey allelic variation and to follow chromosomal segments in breeding programmes through generations. Knowledge of which chromosomal segments correlate with desirable and undesirable traits allows for the rapid selection of plants with the desired traits. Genomics provides for the first time the means of surveying all genes in plants essentially simultaneously. Because plant breeding involves the recombination of genes and chromosomal segments, genomics and plant breeding superimpose themselves on one another naturally.

The field of rice genomics has opened up extremely rapidly over the past five years due to publication of the nucleotide sequence of essentially all the chromosomal DNA of rice. This extraordinary achievement changes the options and methods of rice breeding for all time. It is very relevant for the CGIAR and IRRI to query which countries and organizations will lead in the new technical innovations of genomics that will drive rice improvement in the future. This can be predicted in general terms but it is difficult to make precise predictions.

A brief survey of recent events in rice genomics will serve to illustrate how the situation has changed so much. It reveals that investments outside the CGIAR are driving the future genomics based approaches to rice improvement. CGIAR’s investment in rice genetics is being and will continue to be dwarfed by other investment and organizations across the world and across life sciences.

The Japanese took the lead in the late 1999s by providing a complete DNA sequence of a *japonica* variety for the world but soon found that, to complete it, an international effort was more sensible and appropriate, especially given the examples of how the sequence of several other species were completed via planned, coordinated international efforts. This ‘perfect’ version of a rice genome is expected to be published in 2004 or 2005. However, both

Monsanto and Syngenta have published separately, 'draft' versions of a rice genome sequence. It is probable that these companies spent over US$80 million to gain these DNA sequences on rice varieties. A Chinese laboratory has also announced a complete genome sequence for an *indica* rice variety, performed at a very fast pace, and published it with descriptions of what genes could be found within it.

Estimates of 30,000 to some 50,000 genes have been predicted in rice chromosomes. However, it is very difficult to accurately predict genes in DNA sequences and so there will be a long-term effort to gain correct annotations of the genome by numerous projects worldwide, involving a large number of plant scientists in the public and private sectors. New concepts of genes and their role in determining traits are emerging from large investments in arabidopsis research and transferred to knowledge on rice. The technologies that have brought all this about were developed outside plant science.

Thus we note that, in contrast to previous decades, the information platform for advanced rice breeding in the public sector has been facilitated by some large investments by, for example, Japan, China, Monsanto and Syngenta, as well as the US and EU Governments. These investments total hundreds of millions of dollars and were made outside the CGIAR planning framework.

To make the genome sequence useful for plant breeding it is necessary to relate predicted or known genes and genetic variation to phenotypes or traits. A trait is usually determined by combinations of genes and so it is necessary to connect combinations of DNA sequences to traits. Substantial programmes originating in China, Japan, Europe, Australia, Korea India and the USA have emerged to do some of this and some of the leading laboratories have formed an informal consortium, the Rice Functional Genomics Consortium, under IRRI's leadership.

Given the dramatic change in both the scale of investment and places of discovery in science underpinning rice breeding, what have been the implications for IRRI and its breeding programmes? IRRI reacted, following the challenge from the 5th EPMR, to the possibility that it would be left behind in the building of platforms of discovery for rice breeding. It found itself in this position due to a combination of rapid decision making by other governments/organizations, technical developments outside rice biology, completely inadequate CGIAR resources, and a failure to recognize how rapidly the centre of gravity of rice molecular genetics research would move out of IRRI and the CGIAR. IRRI needed to be on the inside of the progress and capable of using new information. It has thus expanded its capabilities in bioinformatics, created an open source database on rice genomics/genetics for its own purpose and its partners/clients and sought special links with the major information providers. It has equipped a new laboratory to ensure it can use the latest molecular biology technology in the assessment of genetic variation and gene expression and has created and provided thousands of lines which collectively are likely to carry a mutation in most genes. This very valuable germplasm, if exploited by others around the world, will help IRRI to remain a valued contributor to current rice genomics/genetics.

Today, IRRI is recognized as a contributor and valuable actor in rice molecular genetics, even though its competitive investment is not very large. What about the future? What should its role be in serving the NARS and helping to alleviate poverty? What can its role be?

One of its primary declared aims is to put into the hands of breeders knowledge and systems for exploitation of the International Rice Genebank Collection it houses, on trust, on behalf of mankind. These can be radically mined now compared with 10 years ago and opportunities will emerge very rapidly. The goals of the International Functional Genomics Consortium include providing information or a function for each and every gene in the rice genome within a decade. Already, sufficient genetic materials are available to enable every QTL to be traced by a molecular polymorphism in many rice breeding lines and this will be extended to ensure that the knowledge and tools exist to track and stack any chromosome sequence in a directed way in a breeding programme. IRRI can be and is planning to be a major contributor to this goal. The existing major actors will continue to be major actors also. A major question remains: is IRRI going to take and sustain the lead in helping the scientific community worldwide to fulfil the dream of mining the vital genetic information that is in the germplasm it holds uniquely on trust for the world and in disseminating the information worldwide via linked databases? If it does not do this, the arguments for the germplasm remaining with IRRI may lose value and CGIAR's position be undermined.

The building of correlations between polymorphisms in DNA sequences and phenotypes is a very large activity in human genetics and in the large private sector plant breeding companies. They are driving the innovations that are key for increasing speed, reducing costs and thereby enabling adoption. There will be many surprises. Small biotechnology companies as well as large knowledge suppliers are likely to become significant suppliers. It is hard to predict therefore what will be the acceptably cost-effective way of defining and measuring genetic variation embedded in 100,000 rice genotypes and linking this to phenotypes and the design of directed breeding programmes. It is unlikely that IRRI will be at the forefront of the innovations and their application to crop plants. So it must be decided how and where new investments and partnerships are made by IRRI/CGIAR to attain the new reachable goals faster and cheaper. Perhaps the most likely model will be to outsource some of the very high throughput molecular biology tasks via a consortium to the private sector or to some as yet unidentified laboratory in China, India or the USA.

While it is difficult to predict how and with what technology the goals of finding a function for each rice gene and tracking markers in breeding programmes will be reached, it is reasonable to assume this will get done with or without CGIAR funding over a decade or so and that the information will be in the public domain.

Many were surprised to learn that Monsanto and Syngenta invested perhaps US$100 million to sequence the rice genome when there is little profit to be gained from rice and it is not a crop of apparent direct interest to them. The reason for the investment is the genetic synteny between grass genomes and the opportunity to file patents on a large collection of monocot genes. Discovery of the gene-order along rice chromosomes predicts the order along maize and wheat chromosomes as well as along barley, sorghum and millet chromosomes, etc. Thus, knowing the genetic linkages in rice predicts genetic linkages in maize, thereby enhancing the efficiency of designing more competitive molecular breeding strategies for maize. There is more than enough profit in the USA maize market to allow investment in sequence knowledge gathering in rice.

The existence of genetic synteny amongst the grass genomes has also opened up the question of how much rice research will get boosted by the reverse flow of information from maize. The USA commercial and public sector investment in QTL, mapping, genomic analysis and genetics in maize is relatively huge and destined to increase as plant genomics/genetics becomes more efficient. Within 5 years it is likely that the complete maize genome will also be sequenced. The information flow on the linkage between maize genes and traits will accelerate and this will become applicable to guide rice research. Therefore, going forward it must be realized that the global investment in molecular genetics underpinning breeding in maize, wheat, etc. will be helping rice breeding indirectly or directly. Add to this the worldwide discovery of useful transgenes that can be deployed across species and it should be recognized that the CGIAR investments in rice research will be dwarfed by other investments of somewhat direct benefit to rice breeding. One asks therefore whether the CGIAR will define or play much of a part in the decision making of investment in rice molecular genetics underpinning the world's rice breeding from 2010 onwards. This would leave IRRI in a changed and difficult position versus its undisputed status and role in the past.

The Panel members urge that the Science Council and the CGIAR react to the fact that the future scientific basis of rice breeding for the poor will be determined by the investment strategies, policies and discoveries of others. It would appear that the CGIAR needs to participate in broader based collaborations and partnerships to facilitate its mission on rice, let alone on all its other crop improvement missions.

1.7 Intellectual Property Rights, Transgenics and Relations with the Private Sector

Throughout the world, major changes are occurring in relation to IP in research and business, including plant breeding. The Convention on Biological Diversity declared that nations have sovereignty over plant genetic resources in their territory. This, in turn, led to the International Treaty on Plant Genetic Resources for Food and Agriculture, soon to come into force, considered crucial for continued exchange and advances in plant breeding. In the agreement, the majority of food crop groups, including all the *Oryza* genus are included in a multilateral system of exchange, thus enabling IRRI to still exchange rice germplasm with others under agreed conditions.

Under the TRIPS (Trade-Related Aspects of Intellectual Property Rights) agreements of the World Trade Organization, most leading industrialized countries have complied with the adoption and enforcement principles to protect their germplasm while most developing countries have focused on meeting the minimum standards that apply to them. IPR and ownership principles, long established in many industrialized countries, have been specifically introduced to protect inventors and to stimulate investment in innovative R&D. Patents and other rights are granted, based on novelty and utility criteria, in response to specific applications for enforcement in specific countries. Legally granted IPR on technology signifies that persons or organizations not holding licenses to the particular property are not free to use the protected property or make products from them in the specified territories.

IRRI, as an international Centre, must adhere to germplasm ownership and IPR legislation and principles. This means it is neither free to use all technologies and germplasm for research nor to distribute products made with technologies that carry ownership rights, in the absence of appropriate MTAs and licenses. This is a major operational change from a few years ago and the consequences must be recognized by donors and client countries.

This means that IRRI is not free to adopt all state-of-the-art methods and technologies to carry out its mission. These facts are inconsistent with the principles on which the CGIAR was founded, namely that all the CGIAR Centres should create only international public goods and distribute them to anyone who requests or needs them. The inconsistencies create many difficulties for IRRI and the other Centres today and demand new operational strategies.

For IRRI, the implications are substantial and will become more so during the coming decade. Some of the biggest gains for agricultural productivity are likely to come through the adoption of transgenes and the use of germplasm where there are restrictions on use. This has already been demonstrated by the adoption of transgenes conferring pest, herbicide and disease resistance and soon to be further illustrated by a host of other genes including those conferring drought resistance. It can also be expected that many of the genes discovered by the private sector from its sequencing of the rice genome will have been submitted for patenting in some countries and will continue to be submitted as valuable new utilities for them are discovered.

With this scenario of the source of future proven breakthrough advancements in germplasm improvements, the issue is whether the poor are going to be served by IRRI with top quality proven science and discoveries, patented or not, or only with unprotected, probably less proven and inferior technology that takes longer to develop.

The challenges have already been exposed by the leading transgenic technologies to date. Bt transgenic technology has been championed by China and many other countries. One can imagine that individual countries will independently make internal decisions and possibly/probably enable adoption of the technologies more efficiently than happens in the international Centre. This is a serious issue for the perceived role of the Centre and can lead to a serious undermining of that role.

Who holds the IPR that IRRI needs to use? Besides the private sector, many universities in the industrialized countries file for patents on their leading discoveries. Thus, IPR should not be considered as being synonymous with profit-making industries. The problems created by IPR for agricultural development for the poor have been recognized and initiatives have been taken to encourage leading universities and companies to donate technology for humanitarian purposes in aid of the poor, as defined by various criteria, so as to avoid many of the problems. The level of success of these initiatives remains to be seen. They are unlikely to remove the problems in Asia and rice growing countries elsewhere.

1.8 Who Decides What CGIAR Centres Do?

There are natural tensions between the many components of the CGIAR system. The CGIAR is not a legal entity and all its donors have a seat at the table, making it rather impotent as a decision making body. The Centres are legally autonomous and each Centre Board has the authority and ultimate responsibility for determining and carrying out its programmes and policies. However, the CGIAR has recently re-established its scientific advisory group in a new Science Council that is envisaged to have some jurisdiction over the science of the Centres. Furthermore, as witnessed by the strong growth in special project funding at the expense of core funding, donors obviously have strong wishes, divergent from each other, with respect to what the Centres do. In addition, last year the CGIAR introduced Challenge Programmes to which it is expected the Centres will bid and win funds. A significant portion of the funds come from the previously expected budgets of the Centres. Whatever their merits, these Programmes necessarily distort the Programmes of the Centres away from previously accepted, presumably high priority goals and Trustees were not consulted about these changes.

All of these issues create difficulties for all members of the CGIAR family. They create difficulties in particular for the Centres' Management and Boards of Trustees. Difficulties need to be resolved or minimized, otherwise they sap energy from the science and purpose of the Centres, create cost inefficiencies and, especially, undermine the aspirations of talented people. IRRI is no exception and many issues stemming from these structural tensions were noted.

While it is not the place for an EPMR to solve these tensions involving multiple layers of leadership, the Panel nevertheless strongly urges that they be addressed because, if allowed to fester, they could so greatly reduce the effectiveness of the system, including IRRI's, that much potential to decrease poverty will be needlessly lost.

1.9 Conclusion

This EPMR has been conducted at a time when there is still a need for more rice, although there is evolvement towards sufficiency from the dynamic thrusts of previous decades in some favourable areas, and continuing inadequacies in other areas. We ask: what are IRRI's comparative advantages in continuing to address these needs. At the time of this EPMR, IRRI and the CGIAR are facing extraordinary scientific opportunities, but also - as is often the case - new threats and concerns. The question is how can and how will IRRI take advantage of the new science so that it will not become marginalized in 10 years time, but will instead become an actor in one of the most spectacular contributions to crop biology of all times and a leader in harnessing it for the poor.

CHAPTER 2 - GENETIC RESOURCES, CONSERVATION, EVALUATION AND GENE DISCOVERY

2.1 Programme Overview

In 2001, IRRI implemented a new Medium-Term Plan (MTP) consisting of 12 focused Projects across four Programmes. Programme 1, entitled 'Genetic Resources Conservation, Evaluation, and Gene Discovery' contains two Projects.

The first Project, 'Germplasm Conservation, Characterization, Documentation and Exchange', continues efforts of IRRI to collect, conserve and exchange the genetic resources of rice, and strengthens efforts to characterize and evaluate the conserved germplasm, explore alleles for important traits, and develop integrated information systems for all rice germplasm. The broad goals of the Project are thus to protect the biodiversity of rice and to make it and related information available worldwide for the enhancement of rice productivity and scientific discovery.

The second Project of Programme 1, 'Functional Genomics', aims to understand the biological functions encoded by rice DNA sequences, taking advantage of investments made in the public and private sectors in sequencing and annotating rice genomes. The Project involves experimental work leading to gene discovery and developing genetic databases as international public goods, via Project 1, to assist NARS in the discovery of new genes and development of better traits via breeding.

These Projects are involved in the CGIAR Genetic Resources Challenge Programme, 'Unlocking Diversity in Crops for the Resource Poor'.

The value of Programme 1 cannot be evaluated in isolation from the overall IRRI research agenda as it also is constructed to supply basic and supportive information and materials to the breeding activities in Programmes 2 (especially in biotic stress tolerance genes) and 3 (especially in abiotic stress tolerance genes), where some of its impact will therefore be generated.

2.2 Germplasm Conservation, Characterization, Documentation, and Exchange

2.2.1 Project Goals

Efficient exploitation of rice biodiversity provides the opportunity, through plant breeding, to enhance the fitness of varieties for the environments, management practices and purposes for which they are needed. The combinations of allelic variants that have emerged from natural selection and from previous selections by man cannot be reconstructed, so their collection, conservation and evaluation are an extremely important activity for the future food security of mankind. IRRI carries the major responsibility in the CGIAR for rice germplasm.

Use and sharing of such germplasm has many beneficial outcomes including:

a) conservation of the biodiversity of rice species as public goods;

b) production of new high-yielding rice varieties;
c) discovery of the genes and their products related to desired traits, such as resistance and tolerance to many biotic and abiotic stresses;
d) development of improved varieties adapted to variable and fragile environments;
e) knowledge of allelic variation, haplotypes, population structures and the evolution of rice;
f) elucidation of QTLs and the isolation of the genes related to QTLs; and
g) enhancement of information linking the genetics of cereals in general.

This Project covering the conservation, documentation, analysis and dissemination of rice germplasm and its associated knowledge is therefore central to IRRI's and the CGIAR's mission. The budget of this Project was US$1.86 M in 2002 and is projected at US$2.64 M in 2004. The 3.4 IR FTEs (full time equivalents) comprise germplasm management and biosystematics experts, statisticians, bioinformaticists, molecular biologists, breeders and a GIS specialist.

2.2.2 Project Evolution

2.2.2.1 The International Rice Genebank Collection

Collection and conservation of wild and cultivated rice accessions have been a key underpinning activity at IRRI from its beginning. The collections have grown over the years and they have gained appropriately high status. They are maintained as public goods, and most of them are held in trust as designated germplasm under the auspices of FAO. Huge numbers of organizations and individuals have requested and been supplied with seeds over the years for breeding and research purposes. In IRRI, The Genetic Resources Centre is responsible for the collection, conservation, curation and distribution of the International Rice Genebank Collection (IRGC) that currently contains over 108,000 rice samples. IRRI's germplasm collection is believed to represent a large fraction but certainly not all the biodiversity of rice.

In 1993, the Convention on Biological Diversity declared that nations have sovereignty over plant genetic resources held in their territory. This resulted in the need to agree on terms under which germplasm essential for food and agriculture could continue being freely exchanged amongst researchers and breeders. The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) was adopted in 2001 and is soon expected to come into force. The IARCs will join this through re-signing an agreement with FAO. Under the ITPGRFA, the entire *Oryza* genus is included in the multilateral system of exchange, which secures access to germplasm, subject to a Material Transfer Agreement (MTA). To comply with the spirit of the agreement, IRRI and other IARCs concerned with genetic resources will apply similar conditions to the exchange of materials bred at IRRI, which already is subject to an MTA, now being revised.

There has been growing concern within the CGIAR and the larger stakeholder group, of the sustainable funding of the CGIAR's germplasm collections, which currently are dependent on core resources. In response, the CGIAR with the leadership of IPGRI and together with FAO, launched a campaign to attract financing for an endowment fund. An independent Global Crop Diversity Trust has now been founded and eventually any genebank globally will be eligible for funding, providing that they fulfil certain quality criteria related to maintenance. The trust's objectives are to provide a permanent source of funds for the long-term conservation of the *ex situ* germplasm, including characterization, documentation and evaluation, and sharing information, knowledge and technologies to enhance the use of these resources. This is an important development for IRRI and other Centres in a situation of declining core funding.

2.2.2.2 INGER

The International Network for Genetic Evaluation of Rice (INGER) is a formal network among the NARS of the world's main rice growing countries and three IARCs, IRRI, WARDA and CIAT, established in 1975. In the early 1990s, as a consequence of a long-term donor pulling out the funding, INGER's operations were seriously threatened by a funding crisis. The 5th EPMR Panel recommended that the Council for Partnership on Rice Research in Asia (CORRA) take action to reinvigorate this partnership for the common good of NARS and IRRI breeders. Since 1999, CORRA has been serving as INGER's Steering Committee, guiding its broad policies and overall direction, namely the safe international exchange and evaluation of elite germplasm. INGER is managed by the Plant Breeding, Biochemistry and Genetics Division at IRRI. Key NARS scientists serve as technical advisers of INGER.

2.2.2.3 The Biometrics and Bioinformatics Unit

The 5th EPMR also recommended that IRRI evaluate carefully the developments in bioinformatics and develop a new strategy to secure in-house capacity in this evolving field. IRRI consequently reformed its former biometrics unit into the Biometrics and Bioinformatics Unit (BBU), which has developed a comprehensive data management system to link, for example, germplasm and bioinformatics information, nursery performance, pedigrees, and field performance of varieties. The BBU is therefore an essential ingredient for Programme 1 but it also provides the biometrics needs for all IRRI's research programmes. In addition to undertaking statistical research and consultation, scientific computing and database development, it provides consultation and training support to other groups, including the functional genomics Project. Its vision encompasses the need to ensure global public access to high quality informatics technology and information in support of rice agricultural research and to promote long-term capacity building in biological informatics including residential and outreach training in statistics, information management and bioinformatics for the NARS.

2.2.3 Achievements and Impact

2.2.3.1 Genetic Resources Centre

The IRRI genebank is the world's largest and most important collection of rice genotypes. It was cited in a recent external review as "best in the CGIAR system" and "a model for others to emulate". The staff at The Genetics Resources Centre were awarded the 2003 CGIAR prize for 'Outstanding Scientific Support Team'.

The rate of germplasm collecting has been reduced in recent years in the belief that the *Oryza sativa* collection is relatively complete and in order to target resources to other activities related to germplasm curation. This was probably a reasonable decision but the Panel suggests that attempts to stimulate projects to get as complete a collection as possible should be sustained. This makes practical sense because, as molecular marker technologies increase in efficiency, it will be possible to assay new material efficiently for new segments of chromosomes and new combinations of alleles not previously included in the collections.

Also, the IRRI collection is biased towards *indica* types. It appears that *japonica* acreage could increase in the future and therefore acquisition and evaluation of *japonica* germplasm should also be considered a priority.

Despite the slowing down in collecting activity, a substantial number of new accessions has been deposited with the IRGC over the past five years including some 4,000 *O. sativa* and 200 wild rice samples. Wild rice accessions have already been shown to be useful sources of traits not found in cultivated accessions (e.g. resistance to rice tungro virus). In collaboration with NARS, two genotypes (Matatag 9 in the Philippines and AS996 in Vietnam), with genes from *Oryza rufipogon* were released and have been grown on over 100,000 ha. These provide tungro virus and aluminium toxicity tolerance respectively. Another success is the introgression of genes conferring resistance to African gall midge via an IRRI-WARDA collaboration. Due to the high potential utility to breeding of wild species of rice, their curation is important.

Special emphasis has been placed on understanding the biosystematics and classification of the wild rice species using a variety of cytogenetic, biochemical and molecular technologies. Wild rice has been shown to be a useful source of genes that have not been found in cultivated rice accessions and so this activity seems very worthwhile. There has been continued devotion of resources to *in situ* and *ex situ* conservation of rice cultivars from and in Laos. The *in situ* conservation activities are integrated with participatory development of improved varieties from traditional varieties.

There is some backlog in the management processes in the genebank, including documentation of accessions, which require attention in order to make the material available. The emphasis on maintenance of the accessions is important. New seed has been produced for over 40,000 samples and, overall, germination rates remain high. In the last 5 years, over 1,000 batches of seeds, representing over 70,000 samples have been sent to over 59 countries. Information on over 2,000,000 germplasm samples has been distributed to over 450 recipients in response to specific requests. These numbers reflect the interest and value of the IRGC and also the scale of the continuing task of curating the world's rice germplasm and serving the various user communities. These tasks increasingly need to be carried out with compliance to international standards and policies.

The IRGC activities have included necessary improvements in data management, quality control, databases and on-line accessibility. The conversion from the old IRGCIS database to IRIS, to allow many more data streams to be combined and be accessible on line, is necessary and IRRI has been devoting substantial resources to the transfer. Web development is a continuous process to do justice to growing expectations, standards and new data. IRRI continues to make data available on CD ROMs for those without convenient Internet access. Partners are being encouraged to develop better non-English interfaces.

A new commitment has also been made to characterize the phenotypes of the accessions. This is being done through specific in-country evaluations, as well as in Los Baños. This is a special challenge given the complexities of phenotypes being dependent on the environment.

A core set of *O. sativa* accessions has been carefully selected for establishing the first round of genotype-phenotype studies. It is expected that DNA from all the core set accessions will have been made by the end of 2004. Various very good approaches are being adopted to carry out the analyses both in house and in state-of-the-art laboratories in ARIs, as described in Project 1. Specific mapping populations have also been chosen for special study, especially to locate drought QTLs. Alternatively, molecular genetic loci have been chosen and correlations of their map positions with known traits and QTLs have been studied. IRRI's strategies for linking traits and genes are well conceived and have influenced those subsequently adopted by the Challenge Programme 'Unlocking Diversity in Crops for the Resource Poor'.

2.2.3.2 INGER

During the review period, IRRI and other IARCs contributed 1,687 and 344 elite materials respectively to INGER. The number of contributions from NARS declined from the mid nineties until 2002, the total being 93 only. The decline may have resulted from the uncertainty of the rules applying to germplasm exchange and the trend is now starting to change positively as evidenced by the 139 NARS varieties contributed in 2003. In 1998-2003, INGER distributed 53,200 seed packets representing 11 ecosystem-based and 9 stress-oriented nurseries to 45 countries. INGER also distributed more than 2,000 seed packets of INGER entries to scientists at request. Thirty-three INGER lines were released as varieties in 6 countries in this period. In China, the restorers of 8 recently released hybrids are INGER lines. Release of INGER lines saves around 5 years in research time and resources, and hastens the flow of materials from research stations to farmers' fields[6]. Some 20 NARS utilized INGER materials originating from 39 countries and from 3 IARCs as parents in 1,700 crosses for improving the yield potential, pest resistance, abiotic stress tolerance, or grain quality of local varieties. NARS reported 30 released varieties where an INGER line was one of the parents. The impact of IRRI and INGER in contributing to variety production by NARS partners is clearly significant but more perhaps would have been expected. It is difficult for the Panel to form an accurate opinion of what kind of an impact the volume of exchange described above eventually leads to. However, a recent impact study[7], which included a section on rice breeding at IRRI, confirms that the use of both advanced and landrace materials from IRRI have had significant impact on NARS breeding success. No doubt, an exchange mechanism such as INGER has been and continues to be vital to facilitate this exchange.

2.2.3.3 Biometrics and Bioinformatics Unit

A major thrust of the last five years has been the integration of germplasm information from different sources. IRRI has continued the design of the International Crop Information System (ICIS) in collaboration with CGIAR Centres, advanced research institutes and NARS partners. The rice version of ICIS, the International Rice Information System (IRIS), integrates information on all accessions in the IRGC with germplasm improvement and evaluation data from IRRI and numerous NARS collaborators. The integrated information comes from germplasm collections, breeding projects, and testing programmes, and uses unique germplasm identifiers and common trait descriptors so that rice researchers can

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[6] Evenson, R.E. and D. Gollin 1997: Genetic Resources, international organization, and improvement of rice varieties. Economic Development and Cultural Change. pp. 431-500.

[7] Hossain, M. et al. 2002: International Research and Genetic Improvement in Rice. In: Evenson, R.E. and D. Gollin, 2003: Crop Variety Improvement and its Effect on Productivity. The Impact of International Agricultural Research. CAB International. FAO.

implement knowledge intensive crop development strategies. IRIS is also being developed to integrate genealogical and phenotypic information with genetic and molecular characterization contained in local databases and in international bioinformatics resources. For the first time it is now simple to trace pedigrees back to their original sources, and also to trace the flow of genetic resources to released varieties around the world. The BBU has developed a stand-alone breeder's interface with read and write access and has also provided web access. Now BBU is designing an interface for genetic resources specialists so that genebank collections can be managed directly through ICIS. New web-based technologies are being adopted to deliver full, distributed read and write access to IRIS in the future.

2.2.4 Vision and Future Objectives

The EPMR wishes to draw special attention to this Project because the opportunities to use the conserved germplasm are now entering a new era that will increase enormously its value and widespread use. It should therefore be recognized again, by all, as a resource of incalculable value and the investments necessary to enhance its near-term value for the world should not be spared. The goals and vision of IRRI in connection with the rice germplasm collection are excellent and strongly supported by the Panel. In the next few years, the genetic diversity in the genebank can be and should be characterized in increasing detail using molecular biology fingerprinting technologies, and database innovations introduced so that all this information is made available to the world at large in user-friendly searchable forms. Such advances usher in a new reason to appreciate the whole of rice germplasm worldwide as a single pool to be sampled in a directed way. The information in individual chromosome segments should be linked to all other data on rice germplasm – phenotypes, genotypes, yield trials, tolerance to stresses, adaptation to particular environments, preferences of consumers and use by farmers, and therefore be selected in breeding programmes to achieve defined goals. This will fulfil the dreams of collectors, breeders, geneticists, farmers and consumers. The power of gaining all this information and making it available to all should not be underestimated. It is now within reach.

IRRI has a large comparative advantage to empower this global germplasm analysis initiative because it has built up the germplasm collection and knows it better than anyone else. It has the molecular genetics expertise to understand and inspire a global programme, and with its partners is organized already to perform the vital, but challenging, phenotypic evaluations in multiple environments and under biotic and abiotic stresses and to centralize the results. IRRI is well connected with the ARIs who will also provide advice, leadership, results and resources. In addition, few institutions can come close to providing guaranteed safe long-term storage of these genetic resources together with the level of expertise that is required to co-ordinate, analyse, exploit and manage the data for the poorer countries. IRRI is, without doubt, with its international status, the best organization to provide open access to the germplasm and information under the international conventions.

The Panel therefore strongly supports the ongoing conservation of rice germplasm in the GRC, the aim of the GRC to stay at the forefront of germplasm curation, research and management and its collaborative ethos with its NARS and other partners to characterize the germplasm in multiple environments. Its prioritized research programme of improvements in data management and quality, revision of the molecular systematics of rice adding GIS data, removing backlogs and upgrading of the facilities should be supported without interruption. It must continue to foster the strongest working relationships with NARS, ARIs and other CGIAR Centres to realize the extraordinary opportunities that are now available for germplasm characterization worldwide in all crops. Links between the databases of IRRI and its partners, with all the associated training, need to be improved. It will be necessary to have the highest levels of quality control and systems in place to ensure that all the links between the seed accessions and other data have the highest accuracy. This will require very special attention.

IRRI with other stakeholders should continue development of a global informatics network integrating information on rice genetic resources, germplasm improvement, evaluation and utilization networked to similar networks for other crops and to other bioinformatics resources through public sequence databases. This network will provide the comparative biology platform and the very important means of making discoveries and transferring knowledge from one crop to another. Geographic Information and crop modelling data bases should be added to the networked data to help unravel the interdependent environmental, socio-economic and other factors that underlie the adaptation and use of rice genetic diversity. Database design and development are now sufficiently advanced in the world, and developed extensively in the past few years at IRRI, as part of the CGIAR initiatives that designing to communicate with each other readily is feasible and necessary. This should be a major investment, in collaboration with specialist database scientists elsewhere, ARIs, NARS and other IARCs.

As part of this initiative, and for many other reasons, IRRI should create an in-house database that allows linkage of any and all scientific and management information. This will facilitate the kind of scientific and management strategies that are essential today. For example, managing germplasm and genetic reagents is intimately involved with IPR and MTA management that needs to be done with diligence and accuracy. Such a database would help manage the absolutely essential quality control checks, tracking all germplasm accessions and observations on them, in all experiments in-house and by others, by bar coding or other such foolproof systems.

All of this visionary Programme should be continuously evaluated, technically, bioinformatically and comparatively with state-of-the-art methodologies as the subject is very fast moving. Many other institutions have comparative advantages and funding to generate particular types of information and will be leaders in parts of the endeavour. IRRI must be a significant and exemplary contributor but its major role must be to champion the global goals, empower others to use the germplasm and screening reagents for their own purposes and to coordinate availability of all the outputs for the world, but especially the NARS of the poorer countries.

2.3 Functional Genomics

2.3.1 Project Goals

In this Project, the tools of genomics are applied to find the genetic linkages between genes, functions and traits relevant to the problems confronting rice production. The Project includes the discovery of genes relevant to IRRI’s short-term breeding objectives and also a contribution to the global effort to find the functions of as many rice genes as possible over the coming decade. It is essential that IRRI takes advantage of the worldwide advances in functional genomics to find valuable, breakthrough genes and gene combinations in rice germplasm.

The value of molecular genomics to IRRI can also be illustrated by the following. Major fundamental constraints make the characterization and evaluation of germplasm difficult. First, most traits of high agronomic relevance have low heritability and high G x E, necessitating multi-location, multi-season, multi-treatment traits for fully comparative analyses. Second, breeding and research targets change, necessitating changes in the evaluation protocols, and repeated evaluation of old germplasm for new targets. A solution to the frequent mismatch between heritability and usefulness in traits is now emerging due to the recent advances in molecular genetics. From combinations of easily scored molecular markers that link chromosomal physical features to traits in a selected collection of germplasm accessions, it is possible to predict attributes of agronomic performance in other germplasm. This is achieved by scoring the DNA polymorphisms and applying the principles of association and linkage genetics.

The time is right, given the publication of near complete rice genome sequences and the high level of activity in generating the tools and markers and applying them to rice in the public and private sectors of numerous countries, also those in the developing world. These tools offer the opportunity not only to recognize and genetically map variation in genomes, but also to discover the expression patterns of thousands of genes under different environmental conditions. These tools are an essential part of plant breeding research today and must continue as an established part of IRRI's and CGIAR's plant breeding research for the NARS.

The goals of this Project include activities in 3 CGIAR Challenge Programmes. The budget for the Project was US$4.40 M in 2002 and has increased to US$4.6 M in 2004. There are 11.56 FTEs comprising approximately 7 IRS and 4.5 PDF statisticians, bioinformaticists, physiologists, geneticists, molecular geneticists and plant breeders

2.3.2 Project Evolution

IRRI has addressed the relevant opportunities for molecular genetics over the past 10 years by gaining internal competencies, hiring some senior scientists with very good experience and establishing collaborative projects with ARIs. In the 5th EPMR, the Panel raised items relating to genomics and IRRI's role and strategy. Since then, IRRI's competencies and commitment have increased substantially as the value of the applications has become clear, transgenic plants have entered commerce in developed and developing countries and NARS have sought leadership and training in the technologies.

Externally, the near complete genome sequences of an *indica* and a *japonica* variety have been published and a huge number of useful molecular genetic markers derived. The technologies for designing unique features of tens of thousands of genes and putting them on to chips and hybridising with RNA extracted from plants, or plant parts, grown in defined conditions have been developed together with analytical methods to infer how and which genes are regulated in concert with developmental and environmental adaptation. Applications of these technologies have progressed rapidly. Methods to locate genes and to find which are responsible for QTLs have also developed. There are many examples in the literature today of map-based cloning of defined genes from rice as well as other plants and other organisms. Thus many of the technologies appreciated 5 years ago have now been reduced to practice to a considerable extent.

IRRI has developed a functional genomics strategy and many of the technologies and skills in-house, as described below, and added them to its arsenal of genetic skills for producing mutants, introgression lines etc. The pace of development of IRRI's activities in functional genomics has been noteworthy.

2.3.3 Achievements and Impact

A new laboratory was opened in 2002 to carry out some of the high throughput molecular biology techniques, especially those for chip array and marker applications. This laboratory, impressively equipped for present needs, provides a research and training lab for IRRI and its NARS partners. Extensive bioinformatics software programmes as well as drafts of the complete genome sequence have also been introduced into IRRI to design and manage the analyses of these sorts of experiments.

One way to identify the function of individual genes is to mutate them and observe the effects on the phenotype, providing the functions are not duplicated in the chromosomes. IRRI has produced such a mutant bank of about 30,000 lines, containing deletions and other chromosome aberrations. These are being distributed to the scientific community worldwide, to help in programmes to identify genes responsible for specific traits. IRRI was particularly motivated to create this set, using its facilities to handle and maintain the large numbers of plants involved, for its own interests and to contribute something very useful and tangible to the rice molecular genetics community worldwide, including the ARIs. Once screened, it is hoped to be relatively straightforward to find which genes have been changed and are responsible for the new traits. IRRI will, of course, be able to benefit from the discoveries made using these lines.

To help discover the genetic location on chromosomes of genes conferring specific traits, IRRI has substituted *indica* rice chromosomes one at a time into a *japonica* background. It has also created other specialized genetic stocks, mapping populations, near isogenic stocks and backcrossed lines. All these lines are to be disseminated to NARS and ARIs to facilitate the mapping and identification of gene-phenotype linkages. IRRI is also interacting and collaborating with labs in the USA that have specialized technologies for identifying plants with mutations in known genes and with other technology leaders. IRRI is commended for taking these initiatives.

There is now an International Rice Functional Genomics Consortium (IRFGC) led by IRRI involving the leading labs worldwide, with the mission to discover as many gene-trait linkages as possible. This is built upon and continues to attract resources from other major funding agencies including agencies in the US, China, Japan, Korea and India. Many students are being trained in the particpating laboratories. The IRFGC provides a formal structure to share resources and develop collaborations between ARI and NARS. Again, IRRI is highly commended for taking this leadership position to stimulate and leverage knowledge from worldwide efforts for its clients and partners.

IRRI established an in-house micro-array facility for high-throughput screening of germplasm to find polymorphisms and haplotypes linked to desirable agronomic traits. This approach is very powerful. Using similar approaches, IRRI has established the means and carried out analyses to find out the expression patterns of a large proportion of the known rice genes and is collaborating in the IRFGC to enhance this knowledge. Some of the chips carrying 65,000 segments of rice genes are obtained from China. IRRI has selected sets of genes that respond to stresses for internal studies and has created chips to study the behaviour of these in detail in different lines, environments and stages of plant development. It is hoped that the results will lead to genes that can be deployed and combined to help in the control of stresses in future varieties. Training workshops focused on the chip technologies have been held for NARS and for the Asian Rice Biotechnology Network.

IRRI functional genomics and bioinformatics staff have won grants to be significant players in three Challenge Programmes, because of their leading skills and resources for tackling complex problems through molecular and database/computational biology technologies. This is a very significant achievement and is resulting in new staff and investments for IRRI in these very high priority areas of the CGIAR.

IRRI has, over the years, illustrated very well the way to use molecular biology to identify important genes that then enable germplasm to be screened for novel alleles. Using the identified genes it is also possible to make transgenic plants possessing a new trait. IRRI has focused on genes conferring tolerances to biotic and abiotic stresses, in line with major priorities. Its approach is to establish phenotype-genotype correlations, by studying the genes located in chromosomal regions where relevant QTLs map and sometimes by also comparing their expression patterns, to home in on the most probable gene candidate underlying the QTL. The work has progressed well and provides models for many such endeavours in the future. For example, some 96 drought responsive genes were identified and several found to apparently co-localize with QTL regions of drought tolerant traits. 365 markers located around these on the genetic map were tested for polymorphisms in 11 parents. Specific markers were thus discovered to conveniently track these genes in breeding studies. In other studies to find genes associated with the very important broad spectrum resistance, QTLs were identified that confer resistance to brown plant hopper. The Spl 11 gene was subsequently shown to be associated with the QTL and so this was then isolated by map-based cloning. That this gene is responsible for the trait was concluded by showing that allelic mutations in the gene correlated with the trait.

Other genes showing changed patterns of expression in the presence of disease resistance genes have been identified and thus are candidates for being involved in the mechanism of trait determination. Lines of rice have been screened for having different haplotypes around these loci to find novel variation. In yet other studies, QTLs associated with submergence tolerance were mapped and markers linked to them discovered. This enabled the sub1 gene to be identified and manipulated. Genes conferring salinity tolerance and phosphorus deficiency tolerance have similarly been localized to positions on DNA fragments for use as markers and to aid verification of gene-phenotype determinations.

All these represent good progress and point the way for how the Functional Genomics Project, working in collaboration with other Projects in-house, is opening up the way to find new alleles of known function in germplasm. This should become a rapid process in the future and should greatly assist the efficiency with which new alleles can be found, tested and built into varieties as appropriate.

2.3.4 Future Strategy and Vision

IRRI notes that this Project will shift in 2004 from the past resource and infrastructure building phase to one where finding and verifying gene functions predominate. There will be a two track approach. The first will aim to produce ready-to-use products via trait-validated alleles or perfectly linked markers for production and deployment of improved plants by conventional breeding. The second will aim, via the IFGRC, to play a role in characterizing the functions of large numbers of rice genes. These two tracks will enable IRRI to bring nearer term value to NARS and facilitate continuing access to the discoveries and tools made by others.

The emphasis in the near term will therefore be to discover the function of as many valuable genes as possible and then variant genes/QTLs and linked molecular markers by utilizing the power of segregational genomics, as discussed above. The focus on the selected core collection of germplasm to begin the assessment of diversity and association mapping should continue with special emphasis. Continued in-house deployment of state-of-the-art bioinformatics, experimental and data analysis systems is also essential. All of this will need to be associated with external networks and collaborations to succeed and with continuous training in-house and with the NARS.

The EPMR endorses this strategy but encourages IRRI to continue to carefully choose its priorities. Finding out what phenotype is affected by a knockout mutation is not necessarily a good guide to how a variant allele will affect the phenotype in agriculture. Furthermore, such mutations will rarely be of use in elite lines. Similarly, activation-tagged lines may not recapitulate their phenotypic variation in an elite line. Thus, even when candidate genes have been identified from the gene-phenotypic correlations, how efficiently can they be used? At best, such knowledge will guide the researcher to screen germplasm for allelic variation to find better variants, but then there is the problem that the behaviour of each allele may be dependent on the genetic background. Haplotype blocks may still also be larger than ideal and linkage of undesirable alleles may still be a problem. Finding the right, rare recombinant may be too expensive. Whatever the difficulties here, the favourable alleles/haplotypes identified will surely often be useable for agricultural improvements. Alternatively, transgenes can be designed with the intention of releasing transgenic-enhanced germplasm to the NARS.

The current complexities in developing transgenic germplasm for release into agriculture and food chains are well known. There are biosafety, regulatory and IP issues which can make costs high, even before the value of the gene is known. Nevertheless, it could continue to be the case that many of the most beneficial, breakthrough improvements in the coming years will be via transgenesis and thus IRRI needs to continue to respond to the NARS wishes to take advantage of these breakthroughs. Fortunately, the private sector and the public sectors in developed and developing countries using arabidopsis, rice and other plant species are screening large number of transgenes and moving valuable ones through field trials towards products. Drought and disease resistance genes are attractive candidates for public and private sector alike. Thus, IRRI can afford to monitor these advances and only commit itself to develop highly selected, NARS approved transgenic varieties when the value, biosafety and IP license issues can be clarified. Consequently, IRRI should not put a high proportion of its resources into this area ahead of progress elsewhere. Its position in the IRFGC enables it to adopt this stance without neglecting the NARS needs. It should also be noted that the number of transgenes that the NARS are likely to release in the next 6 years is probably very few and therefore IRRI has time to choose very carefully which ones should be carried forward to advanced trials.

Some NARS, especially in China, have been trialling transgenic plants for some years, while this has not been possible in the Philippines. This illustrates that IRRI may have constraints that others do not have and may not be viewed as the ideal vehicle to advance this technology for certain NARS. Thus, the Panel sees IRRI's comparative advantage as lying in its first declared tactic, namely the discovery of useful alleles by combining genotyping and phenotyping of its germplasm to identify genes by association and linkage analysis, followed by detailed analysis of the allelic space around such genes in its genebank. This can be done on an extensive scale and thus hopefully deliver specific information and tools to enhance breeding to fulfil a wide range of needs. The data can be structured according to pedigrees, where possible, so that cause and effect can be inferred with high confidence.

IRRI with its partners has the capacity and network linkage opportunities to relate genotypes and phenotypes and to make the information available to the NARS. This is where IRRI should lead the world. IRRI predicts that from the investments and likely advances throughout the world over the coming 10 years, it should be possible to produce a comprehensive rice genome dictionary of alleles/chromosome segments that are valuable for meeting the needs of specific environments, consumer preferences, environmental challenges, farmers etc when introgressed via the precision of marker assisted breeding, overcoming previous difficulties associated with unwanted linkages. It will, of course, also be possible to evaluate the novel genes in novel genetic backgrounds.

IRRI and the CGIAR should make plans to scale-up molecular fingerprinting to a level that will be required in the routine breeding programmes. Selecting multiple QTLs routinely may require the necessity to examine very large numbers of plants. While marker assisted approaches will increase the costs of certain day-to-day operations the outputs may be extraordinary. Consideration should be given by IRRI and CGIAR and their partners to establish state of the art MAS breeding centres for economies of scale. It should be noted that while stacking of many QTLs to create a valuable set of phenotypes can produce outstanding results, the combination is disassembled upon further breeding, as is necessary. This is where insertion of transgenes has an advantage, providing their genetic characteristics can be optimized and regulatory and other constraints associated with these products are not prohibitively expensive.

The EPMR endorses IRRI's plans, with the reservations above, and urges IRRI and the CGIAR to ensure that the IRRI germplasm is evaluated in the field and via molecular markers in a concerted and coordinated effort, using the public and private sectors, with all possible speed and to create the necessary infrastructure to enable high quality data to be released to all, and especially the NARS. IRRI can inspire and empower some of the best plant genetics labs in the world to focus on this goal and with the progress established via the IRFGC and the already demonstrated commitments in funding from various sources, the goal is attainable. This could be the most significant, large goal-orientated flagship Project of the CGIAR and its global partners in the coming decade. Its relevance to opening up progress in breeding methodology and utilization of the world's germplasm resources by the NARS is without parallel in the history of science and plant breeding.

2.4. Overall Assessment

This is an extremely important Programme in IRRI's present and future. It could be the basis of a flagship Programme for the CGIAR. Characterization of rice germplasm using the tools and intellectual approaches of genomics is a high profile subject for fundamental studies of plant evolution, of what gene combinations man has selected in different environments and phases of cultural evolution and as a platform from which to develop a new phase of crop improvement. Rice now serves as a leading model plant and the crop that feeds most people. This combination is very powerful for attracting talented people and new resources.

IRRI has made very good progress since the last EPMR and has assumed a position amongst the leading rice molecular genetics laboratories by demonstrating its comparative advantage for the challenges in this work based on the rice germplasm, by some experimental results, by international leadership, by winning competitive grants and by establishing some high profile collaborations. The formation of and leadership role in guiding the IRFGC is excellent. Staff have also kept up commitments to train scientists from NARS. Now the major investments in developing the subject and facilities for functional genomics and germplasm screening need to be recouped in terms of world-class output.

The leading IRRI germplasm collection now has additional value as molecular biologists as well as breeders seek to discover its secrets and diversity. This importance is also reflected by the international efforts to guarantee long-term funding of collections and enhance their use through global collaboration and networks. The revitalisation of INGER through CORRA is a good success, but this group must be sustained financially in some way. Its remit could be expanded to include the exchange of genes, probes and other molecular biology reagents.

Progress and vision on managing the germplasm collection and making all the associated data available to all on-line are excellent, but selective collecting should still go on to obtain as much of the *Oryza* genus as possible. IRRI needs to maintain the highest levels of curation and management. Its reputation will depend on it.

The internal developments in bioinformatics are good and the design and adoption of IRIS and the transfer of data from IRRI to IRIS so that all can access it on line are particularly noteworthy. The challenge is to integrate IRRI databases with others including different NARS from different countries. IRRI is developing an open source system for accessing databases and considers itself a leader in the CGIAR in database development and networking.

The publications from staff associated with this Programme are reasonable, given that many new things have had to be started in-house. However, the overall rate of 1.8 refereed papers per year and 0.5 book chapters per international staff member (including IRS and PDFs) in subjects covering molecular biology, bioinformatics, breeding and genetics is too low to capture and sustain a high status in the subject of rice germplasm analysis and trait genetics. Scientists working on rice genetics/genomics in many other institutions will exceed this regularly. However, the proportion of papers published in molecular biology, genetics and bioinformatics in high impact journals is reasonable. IRS staff should endeavor to get sufficient, high profile papers associated with IRRI so that the status of the institution in the field is maintained. If this is lost, then the credibility and the opportunity to serve the NARS with leading information and to sustain funding may be compromised. The Panel also suggests that IRRI staff consider very carefully what is worth publishing and where it will have the biggest impact so that all the time spent writing (and attending conferences) is optimized. This is especially important now that additional burdens of Challenge Programmes are being carried by some of these same IRS staff members. The Panel expects that publications will increase in the future as the subject moves on and IRRI's experience grows.

The scale of the opportunities and responsibilities of this Programme are far beyond IRRI. The EPMR is pleased to see that IRRI knows that partnerships are absolutely essential. It can never be done without INGER, ARIs and other CGIAR Centres. IRRI has made a good start in building on its strengths to ensure that these linkages and networks are in place. IRRI must continue to drive the global vision and inspire and empower others, wherever and for whatever reason, to join in the big push to make disseminated knowledge on rice as second to none on the planet. The value of what will flow from this is beyond the minds of us all.

With this position IRRI and the CGIAR assume much responsibility. The standards required in the molecular biology, germplasm annotation, database and bioinformatics to fulfil the expectations are very challenging. IRRI must therefore adopt very high quality control standards and systems. It should take the opportunity to learn from the leading private sector laboratories and those leading the field in human genotyping and mapping. Careful management of IP matters and MTAs is very important as expressed elsewhere.

Because the scale and scope of the opportunities are so extensive and attractive, IRRI should be ruthless in selecting what it does internally in functional genomics. It must focus on discovery of QTLs that will help address bottlenecks and the needs of the poor and methods to make plant breeding more successful. The choice to explore first stress and disease related genes makes sense, and progress to identify them has been very good. Genes that enhance grain yield in valuable ways, and also quality, are also good selections in principle. The EPMR is pleased to see the interactions with Programmes 2 and 3 and considers that such interaction and commitments are essential to extract the value out of Programme 1 to fulfil IRRI's mission. IRRI should plan to adopt larger scale marker assisted breeding technologies as progress makes this justified. Consideration should be given to establishing a state-of-the-art lab for handling the very high throughput needs of several CGIAR Centres or simply outsourcing to specialist organizations where this is cost effective and reliable.

Overall, the conclusion is that IRRI has made good progress to help stimulate the global challenge to understand rice germplasm diversity and to develop methods and information to help improve breeding successes. However, the challenge is a global one and fortunately a large number of specialist institutions are already involved but their outputs need to be coordinated to maximize the value of their efforts. IRRI can continue to contribute to this role with the right sensitivities and sustained scientific standing.

It will take a relatively large amount of money to achieve the long-term extended goals of the Programme. Fortunately, many governments, companies and ARIs outside the CGIAR have a similar vision and are spending much more money and training people, and are therefore also contributing to the IRRI vision.

Five major priorities for action stand out:

- Maintenance of the IRGC;
- Phenotyping and genotyping of the selected set of accessions;
- Continuing careful selection of the QTLs and genes for improving germplasm selection by IRRI and NARS breeders;
- Dissemination of information on rice for the NARS; and
- Planning of high throughput facilities for application of marker-assisted breeding as required by the breeders in the future.

The Panel recommends that IRRI stimulate the global community to establish gene-phenotype linkages in carefully selected germplasm in a targeted way, as rapidly as possible, for purposes of plant improvement, making results available to all. IRRI should report to the Board of Trustees by April 2005 on its progress in implementing this initiative with its partners.

CHAPTER 3 - ENHANCING PRODUCTIVITY AND SUSTAINABILITY OF FAVOURABLE ENVIRONMENTS

3.1 Programme Goals

Programme 2, 'Enhancing Productivity and Sustainability of Favourable Environments', maintains its vision is "to alleviate poverty by increasing on-farm productivity, and ensure continued increase in rice production to meet population growth, while ensuring rice prices continue to decline, through reducing input cost". IRRI and the collaborating NARS breeding projects for irrigated and favourable rainfed environments see their role as a combination of maintenance breeding (to counteract disease and pests, maintain current yield performance) and improving yield and quality traits. The natural resource scientists' vision is of sustainable, resource-efficient farming systems that will use less water for more crops with less wasteful or marginal agrochemical and fertilizer inputs. In developing sustainable systems, they plan more use of the long-term experimental data available to IRRI from many localities to identify the most effective combinations of agronomic practices for different environments, as well as short-term tactical experimentation. The emphasis here, and through the delivery mechanism afforded by the Irrigated Rice Research Consortium (IRRC) is to move into an era of 'knowledge-intensive crop management'.

The Programme consists of four Projects, with a total budget of US$10.29 M in 2003 and 24 FTE international scientists, including post doctoral fellows. Table 3.1 shows the distribution of resources between the Projects in 2003.

Table 3.1 - Distribution of Resources Across Projects for Favourable Environments, December 31 2003

Genetic enhancement	Managing resources	Water productivity	Irrigated Rice Research Consortium
8.90 FTE	9.65 FTE	3.10 FTE	2.40 FTE
US$ 3.44 M	US$ 4.38 M	US$ 1.85 M	US$ 0.52 M

The objectives of the individual Projects are:

Project 3, 'Genetic enhancement of yield, grain quality and stress resistance': to develop rice varieties with at least 20% higher yield potential, improved grain quality and durable resistance against major pests.

Project 4, 'Managing resources in intensive rice': to develop and evaluate decision tools, environmentally safe and efficient farm management practices and appropriate farm machinery to bridge the yield gap between existing production systems and potential of modern varieties, in environmentally sound ways.

Project 5, 'Enhancing water productivity in rice systems': to develop socially acceptable and economically viable novel irrigated rice-based systems that give options to farmers to save water in rice cultivation.

Project 6, 'Irrigated Rice Research Consortium': to provide a suitable structure and mechanism to facilitate technology impact in sustainable irrigated rice production to: 1) identify regional research needs in irrigated rice; 2) promote research collaboration; 3) support the integration of research; 4) leverage resources from Consortium members; 5) strengthen multi-institutional and interdisciplinary research; and 6) facilitate technology delivery to impact. Countries involved are Bangladesh, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand and Vietnam.

3.2 Programme Overview

Although almost as much land is used in production of rainfed-bunded or upland (field environments) rice as irrigated rice (59 million ha vs. 73 million ha irrigated), an estimated 77% of the rice yield in Asia comes from irrigated paddy, and the trend over the past 25 years has been for the proportion of rice coming from irrigated land to increase by nearly 1% per year, despite the loss of some paddy land to other forms of development (Table 3.2).

Table 3.2 - Irrigated and Unirrigated Rice Land, Production

Country	Total Rice Area		Total Irrigated	Total unirrigated
	M ha	% Irrigated	M ha	M ha
Bangladesh	10.9	24	2.70	8.20
Bhutan	0.03	19	0.01	0.02
Cambodia	1.9	16	0.30	1.60
China	32.1	92	28.53	3.57
India	42.5	46	19.55	22.95
Indonesia	11.0	54	5.94	5.06
Japan	1.8	99	1.78	0.02
Korea	1.1	71	0.77	0.43
Korea, PDR	0.7	67	0.47	0.23
Lao PDR	0.6	7	0.05	0.55
Malaysia	0.7	66	0.46	0.24
Myanmar	6.3	51	3.15	3.15
Nepal	1.5	47	0.80	0.90
Philippines	3.6	61	2.16	1.44
Sri Lanka	0.9	67	0.60	0.30
Thailand	9.6	9	0.95	8.45
Vietnam	6.4	85	5.44	1.00
Total	133.7		75.7 (57%)	58.0 (43%)

Source: IRRI 2003 Bell and Lapitan, internal document

Rice in irrigated systems is the source of the main bulk of the food that feeds the urban poor, and many of the rural landless. For this reason IRRI continues to place nearly as much emphasis on improving productivity gains from irrigated systems as non-irrigated regions through combined strategies of raising yields, reducing input costs and improving the sustainability of irrigated farming systems.

In the 1998-2000 MTP, IRRI developed its priorities involving both objective analysis and subjective judgements, with a balance across rice ecosystems and regions. During the past five years, some of the priorities proposed for Programme 2 in the 1998 MTP have changed in emphasis or detail with the completion of studies on methane emission from rice fields, and a few new priorities have emerged, including 'Golden Rice','aerobic' rice and post-harvest technologies. The emphasis on 'breaking the yield barrier' has been reduced, and emphasis has shifted to achieving greater yield stability, providing consistently high yields in the field, and integrating systems of breeding and agronomic strategies.

In the latest MTP for 2004-6 the strategies for identifying priorities have not been explicitly described; this is an unfortunate omission. Priorities identified for the next five year period show little major shift from the past, and the Programme vision and main elements remain essentially the same as they were, other than the emergence of a new priority on post-harvest technologies and yield loss reduction for the first time, and a change in emphasis in some specific transgenic applications. So called 'New Frontier' areas of research are no longer identified by this title, and have lost emphasis; others have been incorporated into mainline project areas.

Breeding*:* IRRI has had a long history of searching for ways to obtain major increases in rice yield per hectare, over and above the small incremental increases that derive from conventional breeding programmes. Thus, the New Plant Type (NPT) was initiated in 1989 to develop a radically different rice morphology that could increase the yield potential by up to 50%, by redesigning the plant architecture in terms of energy capture and efficiency of conversion[8]. Early promotion of the concept of the NPT as a 'super-rice' led to unrealistic expectations of yield gains in the early 1990s, but the past five years has seen a more realistic evaluation and solid gains made in producing high yielding varieties that will outperform current inbred lines. The NPT project has also had a spin-off benefit by infusing new genetic variability into the modern genepool of tropical *japonica* lines, now crossed with *indica*, to provide high yielding variety genepools. Secondary traits of exciting potential include better lodging resistance than occurs solely in the inbred *indicas*, higher nutritional quality and aerobic adaptation that is of value to both unfavourable and favourable environments. Genuine progress towards achieving the theoretical potential of the NPT has been slower than originally forecast but yields above 10t/ha have been achieved, similar to good inbred lines. This initiative also stimulated a range of alternative strategies for achieving stable, large yield improvements, including more investment in developing hybrid rice varieties which can yield up to 20% above inbred lines.

Other more conventional breeding strategies that have been equally successful in increasing yield per hectare include shortening the time to flower and ripen, reducing losses from pests, diseases and weeds both by breeding for resistance and competitive advantage.

The pace of new developments in plant biotechnology has quickened in no small measure in the past five years due to stimulus provided to geneticists from the international scientific community's project to sequence the rice genome of *O. sativa* ssp. *japonica*, through the IRGSP. IRRI genetics and plant breeding programmes have benefited from this work. As a result of these developments, it is now possible to make real headway in pin-

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8 Sheehy, J.E. et al. 2000: Redesigning rice photosynthesis to increase yield: studies in plant science 7. Amsterdam (The Netherlands): Elsevier Science BV and Manila (Philippines): IRRI 293 pp.

pointing the QTLs related to such complex traits as grain yield itself, under multi-gene phenotypic expression. While there is a large gap between identifying genes and QTLs, and having well adapted crops growing in sustainable production systems that provide benefits to the rural poor, IRRI's breeding programme is on the verge of bridging this gap with lines incorporating abiotic stress tolerances applicable to both Programme 2 and Programme 3 ('Improving Productivity and Livelihoods in Fragile Environments').

Production systems: At the start of the present five-year period, the principal concern facing Programme 2 was the apparent yield stagnation and possible yield decline noted on continuous rice plots at IRRI Los Baños and elsewhere. While subsequent investigations demonstrated that this problem was most evident in very high yielding, high nitrogen input locations, there were concerns that productivity was stagnating or declining also in long continued high input paddy rice in some farming districts in South and East Asia. In 1999, a CCER was undertaken on this 'mega-project'. Findings showed that, although there had been changes in the soil chemistry and biology of long-continued high input rice monocultures that were constraining productivity, balanced nutrient management without excessive use of nitrogen was the key to sustainable production and fertility maintenance. Subsequent research identified that optimum productivity and sustainability came from reducing inputs and timing these more closely to the phenology of the crop. These have paved the way for a new approach. The 'mega project' was therefore transformed into work on sustainability of intensive irrigated production systems, and continues to underpin the implementation of sustainable production systems that form the current Project 4. This led to the present emphasis placed on site-specific nutrient management (SSNM) which has now progressed from a research finding to a major operational tool distributed through national agricultural agency programmes. This is, in itself, a major shift in scientific attitude towards much more fully integrated systems of sustainable crop production and is strongly commended by the Panel.

In recent years, IRRI's recommended crop and soil management systems have received a strong challenge from a system proposed by Norman Uphoff and others[9]. The system being promoted claims to provide yields that are two to fourfold those from conventional farmers' fields without recourse to purchased inputs. IRRI scientists, collaborating with other research institutions in China, Japan, Australia and the Philippines, have reproduced this production system and compared it with good local farmer practices. In every case, the SRI performed less well than commonly used good practice and the claims for SRI would now appear to be largely discredited in matching high yields in irrigated environments[10]. It has, however, raised interest among donors and some Asian government agencies, as for instance in Lao PDR, because of its reliance on 'organic' production methods. However, numerous studies undertaken at IRRI and worldwide on the nutrient demands of 5-10t/ha grain crops demonstrate that no high yield production system can be sustained even on the most fertile soils without nutrient replenishment. It is the Panel's view that advocacy of this approach could place in the minds of poor nations and farmers, cruelly false hopes of gains in rice yields which cannot be realised.

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[9] Eg: Uphoff N, 1999. Agroecological implications of the system of rice intensification (SRI) in Madegascar. *Environment, Development and Sustainability*, 1, 297-313.

[10] Sheehy J.E. et al. 2004: Fantastic yields in the system of rice intensification; fact or fallacy? Field Crops Research 4316, 1-8.

3.3. Achievements and Impact

3.3.1 Genetic Enhancement of Yield, Grain Quality and Stress Resistance

Project 3 uses conventional and biotechnological approaches to develop a wide range of cultivars that are 20% higher yielding than present high-yield varieties, incorporating durable pest resistance through pyramid breeding and marker aided selection (MAS). IRRI's main role in rice breeding is now, and has been for some time mainly at the pre-breeding stage, to develop potentially useful parents for selection in national breeding programmes, in a truly collaborative set of arrangements that is highly valued by national research agencies.

The major outputs from Project 3 are discussed in following sections.

3.3.1.1 Improved inbred lines possessing high yield, multiple resistance and improved quality

Over the past five years, IRRI has provided 22% of the direct-cross varieties released by NARS and 31% that involved at least one IRRI parent in the cross, most of which have been for irrigated environments. A total of 309 varieties were released for all ecosystems, of which 53% were IRRI breeding lines or the cross involved at least one IRRI parent. This continues a long tradition of international exchange and flow of rice germplasm in which IRRI has been at the hub of the interchange that is rightly described as extraordinary[11], and has been highly successful in maintaining the flow of new varieties released in Asian countries. The Panel commends this continued strong flow of valuable material into national breeding programmes.

There has been a substantial effort to introduce multiple pest and disease resistance into widely grown varieties, and good resistance has been developed against brown plant hopper, bacterial blight and tungro disease. This has been achieved by introgressing lines from wild species, and it represents a significant advance on earlier lines developed for single pathogen resistance. Several NPT lines now have multiple disease and insect resistance, and one of these has also yielded over 10 t/ha in field trials. The Panel considers this to be a notable achievement.

There are exciting new developments in the pipeline with some of the marker assisted breeding products, such as strong QTLs identified for both irrigated and rainfed lowland rice varieties. In close collaboration with the Indian and Bangladeshi breeders, IRRI has identified QTLs for tolerance to moderate salinity for irrigated conditions, increased P-uptake, and tolerance to various toxicities and drought. Using high yielding and popular varieties, such as 'Swana' that is grown in over 20% of Eastern India and parts of Bangladesh, submergence tolerance trait[12] is being incorporated to secure more reliable yields for millions of poor farmers in a mixture of rainfed and irrigated environments.

Other notable achievement highlights for the past five years are:

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[11] Evenson R. and D. Gollin 1997: Genetic resources, international varieties and improvement in rice varieties. Colloquium, University of Chicago.

[12] Xu K et al. 2000: A high resolution linkage map in the vicinity of the rice submergence tolerance locus Subl. Molecular General Genetics. 263.681-689.

- several varieties that show no yield loss under water-saving (alternate wet-dry) conditions;
- excellent performance of Bt (*Bacillus thuringiensis)* transgenic rice in fields infested with rice-eating caterpillars (Lepidoptera);
- several genes pyramided into advanced breeding lines to confer aromatic flavour;
- 'Golden rice' with elevated the β-carotene of first generation varieties, now suitable for Asian consumers; and
- *Xa21* transgenic rice cultivars developed and evaluated in the field in China, Philippines and India.

NPT lines for irrigated conditions now yield up to 10t/ha in some seasons, similar to the yields achieved by hybrid rice varieties or the best modern inbred *indica* lines. Progress was slower than hoped for in achieving high levels of grain filling because early NPT lines, derived from introducing dwarfing genes into tall tropical *japonica* rice varieties, had such prolific panicles that grain filling was never complete by senescence. *Indica-japonica* crosses that introduced genetic traits associated with long grains in place of short grains have overcome much of this problem. Particular emphasis is now being placed on incorporating grain quality such as long translucent, mildly aromatic grains with intermediate amylose content, which are the traits preferred by consumers. As grain filling remains a challenge in NPT lines, the Panel **suggests** that the most useful future work for IRRI to focus on will be the physiological basis to achieving full grain filling, while NARS programmes continue to focus on variety production.

Progress with Golden Rice transgenic rice has been slow because of the necessity to remake all the transgene constructs to satisfy IP requirements, using a different selectable marker. However, progress has been made by IRRI and its partners to get successful transgenics made, with agronomic and health benefit trials undertaken. The Panel considers that IRRI has good leadership to manage these issues.

The situation for the transgenic rice lines has become more complex in the past five years, despite the rapid rate of progress in the science. Transgenic food crops have been the focus of intense public scrutiny relating to consumer acceptance, international trade and regulatory issues on biosafety. Some Asian country policies are enthusiastic, others are more cautious. While the progress made in producing transgenic rice lines that are resistant to a range of pests and diseases was initially seen to have major environmental and cost saving benefits, IRRI must now keep a close watch on their acceptance in the market place. This is therefore discussed in more detail in Chapters 1 and 2.

3.3.1.2 Heterosis, Grain Quality and Resistance in Rice Hybrids

In 2002-3 the average increase in yield of current IRRI hybrids tested against best inbred lines across 15 regions in the Philippines was 31.4%. These are exciting results in IRRI's search for higher yield potentials. Several heterotic hybrids now also have both better grain quality and higher iron content than popular varieties currently grown by farmers. This is important as many of the earlier hybrids were of poor quality with low consumer acceptance. There is general strong interest now in hybrid rice across Asia, not least in stimulating the private sector involvement in participating in seed production. Nevertheless, hybrid seed production is an expensive business and the cost of seed must be recovered by crops that have a higher yield and are of equal quality for farmers to adopt hybrids everywhere. Breeders are pushing ahead to develop two-stage hybrid production systems using environmentally sensitive male sterile systems which will reduce seed production costs.

Hybrid rice is already being grown in many areas of Asia. In China, nearly 18 million ha of the 33 million tonnes of harvested rice land were planted to F1 hybrids as early as 1992. Hybrids are now being grown on several hundreds of thousand hectares in Vietnam, India (280,000 ha in 2003), and the Philippines. The jury is still out on whether these developments are commercially viable and sustainable in the long run. Interestingly, in China, hybrid rice was most successful when the grains sector still had large elements of the command economy, but as it moved towards a more market oriented system, the acreage under hybrid rice dropped from 58% in the early 1990s to 40% in 2000[13]. In Vietnam, hybrids are mostly grown in North and Central provinces where, because of the persistent shortage, the state procurement system plays a bigger role, and not in the South, where market mechanism functions more freely.

On the production side as well, it is important that IRRI comes to a decision on the extent to which it invests in market based criteria in pursuit of grain quality traits, such as fragrance, grain size and colour, and whether to pursue hybrid rice seed production as a major strategy, given the fact that hybrid seed is expensive to produce and must be purchased each year. This may exclude poorer rice farmers from benefiting from its advantages. National breeding programmes and the private sector are already well established in these areas, servicing the needs of the richer rice farmers rather than the needs of smallholders to improve low yield levels and yield stability against the endless threats of pests, diseases and weeds.

IRRI's achievements in pure line developments are very substantial, particularly given the relatively small size of the Programme and the complexity and diversity of the breeding objectives of its NARS partners. IRRI undoubtedly continues to have a very strong impact on national breeding programmes in Asia equivalent to that described a little earlier by Evenson and Gollin (1997), and provides nearly a quarter of the parent material into successful releases. Respondents to the review questionnaire and NARS representatives interviewed by the Panel consistently identified the value of the germplasm exchange, shuttle breeding programmes and the capacity of IRRI's experience in rice breeding and biotechnology expertise as key factors in IRRI's role in the region.

3.3.2 Managing Resources in Intensive Rice

IRRI sees the key to maintaining high yields for the long-term to be a knowledge-intensive 'tool set' that requires integrated management and information packages for farmers and advisors. This has been a major advance in understanding the basis for sustainable, intensive irrigated rice systems, and can been used for a diversity of different applications as production systems change to meet new challenges in the future. Much of this core knowledge is now freely available to all through the Rice Knowledge Bank on the web, and is constantly updated in a very valuable service provided by IRRI (see Chapter 5).

Plant-based rapid assessment of nitrogen requirement, using the Leaf Colour Chart (LCC), is the basis of site specific nutrient management (SSNM). Over 500,000 LCCs have been distributed to date, targeted at irrigated and favourable rainfed lowland areas of tropical

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13 Janaiah A. and M. Hossain 2003: Can hybrid rice technology help productivity growth in Asian tropics? Farmers Experiences. Economic and Political Weekly. Vol. XXXVIII 25, June 21, 2492-2501.

and subtropical river basins which adopted intensive modern rice production early, and have grown two crops a year or more for over three decades. Research findings on SSNM across many sites have verified that this approach improves field-level productivity, with flow-on benefits to individual farmer incomes[14]. To date, environmental benefits have not yet been measured. In the 'three-reductions three gains' campaign in Vietnam, for example, with more accurate placement and time of application of the nitrogen, savings of up to 40% of N-fertilizers were achieved, with savings of US$35-58 per farmer across eleven provinces of Vietnam. Use of the drum seeder results in both lower seeding rates and improved crop health, which also reduces the need for pesticide applications and produces higher yields as a result of the lower losses due to pests.

Through the Irrigated Rice Research Consortium (IRRC, see below), SSNM is being disseminated on a wide scale through partnerships among farmers, public and private organizations, NARS and IRRI at 21 sites in eight countries in tropical and subtropical Asia, each representing large domains (> 100,000 ha) with similar soils and cropping systems. Environmental impact studies are now needed to assess whether reductions in input use are having any widespread effect, and IRRI recognizes that combined economic and environmental *ex post* studies should be conducted in future to demonstrate the gains that are being made with these input reduction programmes.

IRRI is now developing SSNM for other elements such as phosphorus (P) and potassium (K) within a simple framework for farmer application that integrates fertilizer use with other seasonal crop operations. Demonstration nutrient-omission plots identify which nutrients are required and give farmers a tool by which they can achieve balanced nutrition. For example, research results have indicated that hybrid varieties may require higher K applications to achieve full yield in farmers' fields, whereas farmer applications of phosphate have often been found to be greater than are now needed, as residual P contents are high in many paddy soils.

IRRI's contribution to the Rice-Wheat Consortium (RWC) has been a major part of Project 4 over the past decade. The RWC stemmed from the concerns that intensification of irrigated rice-wheat system that occupy one fifth of the grain producing areas of Bangladesh, India, Nepal and Pakistan had started to exhaust the soil and was leading to yield decline, particularly in the wet season rice, from an average of 5 t/ha to 3t/ha in twenty years. As it is estimated that the demand for rice and wheat will grow at 2% per annum in the next 20 years in this region, there was a need for a radical reappraisal of the existing production systems.

The Consortium has been outstandingly successful in developing more sustainable production systems that will be of benefit to many of the 1.2 billion people who live on the Indo-Gangetic Plain. The challenge has been to adapt the land, puddled for rice in the wet season, into a suitable seedbed for wheat and other crops in the dry season and back to rice in time for the next monsoon. In the wetter, eastern ecoregions of the basin there can even be a third crop, provided the rice crop can be planted, grown and harvested rapidly. When conventional rice and wheat production systems are used sequentially on the same land, both crops suffer yield losses. IRRI has been the collaborator responsible for selecting and testing appropriate rice varieties, and developing a range of direct seeding, reduced tillage, weed management, and rice harvesting technologies, that can both maintain or even improve rice

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[14] Buresh, R.J. et al. 2004: Rice systems in China with high nitrogen inputs. In Modier et al ed: Fertilizer Nitrogen Rapid Assessment Project, Island Press, Covelo CA.

yields, while reducing the turn-around time between crops, and adapting this package of technologies to the different agro-ecological regions of the Indo-Gangetic Plain. Despite earlier difficulties in reaching the yields achieved in conventionally puddled systems, yields are now equal to the best conventional crops. Modified irrigation in formed beds, combined with zero tillage and direct seeding, also give substantial savings in water use, labour and fertilizer inputs. This represents a great achievement.

A review of the RWC was carried out in 2003, which praised the successes that had been made in developing these more sustainable and productive systems, but proposed changes to the organization and methods that will be required for the RWC to scale up its activities and extend its impact more widely to the rural poor in the future.

The RWC has emerged as an innovative model for regional and international collaboration, on the basis of its strong and credible record of achievements. Many of these have been compiled and documented[15]. The review recommended that the RWC continue to focus on knowledge generation and exchange of knowledge and people, with IRRI and CIMMYT continuing to provide facilitation and coordination.

In the period under review, IRRI's entomology and plant pathology research has focussed increasingly on IPM systems in which disease diagnosis and incidence, biological control and use of plant resistance breeding are all used, in order to provide rapid tactical assessment of pest and disease incidence severity and appropriate advice on methods of control. Biological control, which was heavily supported in the previous five year period, is still researched as one tool in IPM, but attention has shifted in recognition that biological control cannot at present provide complete protection by itself.

Several studies have been conducted to assess the environmental impact of IPM on rice production systems in Asia. It is now well established that insecticide sprays disrupt normal food web developments in rice ecosystems, creating situations that favour secondary pest infestations, and a similar situation occurs with over-reliance on herbicides.[16] Reduced pesticide use is also beneficial to other aquatic ecosystems, for example by providing better opportunities for fish and shrimp farming, duck raising and improved nutrient cycling within rice paddies. These provide additional economic benefits to farmers and have been the basis of highly successful adoption programmes in the Philippines, Indonesia and Vietnam such as the 'Three reductions, three gains' dissemination programme in several provinces in South Vietnam. IRRI's role in working with NARS to change farmer practices is highly commended by the Panel as a successful achievement that has had great beneficial impact.

3.3.3 Enhancing Water Productivity in Rice Systems

Project 5 reflects IRRI's responsiveness to the looming water crisis in many parts of Asia, in which competing demands for water will force reductions in water available to irrigation farmers. As irrigated rice takes an estimated 55-60% of all water used for human

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[15] Ladha, J.K. et al. 2003: ASA Special Publication 65, Improving productivity and sustainability of rice-wheat systems: issues and impacts.

[16] Heong KL and K.G. Schoenly 1998. Impact of insecticides on herbivore-natural enemy communities in tropical rice ecosystems. In Ecotoxicology, Pesticides and Beneficial Organisms, Haskell PT, MacEwen P, (eds), Chapman & Hall, London., pp 381-403. Ueji M and K. Inao 2001: Rice paddy field herbicides and their effects on the environment and ecosystems. Weed Biology and Management vol 71-79.

purposes in Asia, the greatest gains can be made by improving water use efficiency in rice-based irrigation systems. While rice is exceptional among cereals in being able to grow in flooded conditions, continuous flooding is not an absolute requirement even for paddy rice, and IRRI has been at the forefront of developing alternative production systems that cut the consumption of irrigation water for rice. Experimental results from the experience with the RWC in India showed that 15–40% savings in pumping time can be achieved over the traditional methods of growing paddy rice in the monsoon season[17].

IRRI's research has shown that changes to the water regime of the crop have a number of spillover implications for crop establishment, weed and pest control, and nutrition. Among the disadvantages of reducing flooding time in irrigated systems the problem of adequate weed control is greatest, but plant nutrition and microbial activity are also affected. All of these effects must be further addressed before widescale promotion is attempted, and different technologies are therefore required at different stages of adoption. At present such technologies as drum-seeders and broadcast seeding, surface and subsurface wet seeding, dry seeding, aerobic rice (grown in non-puddled soils with no standing water but supplementary irrigation), zero-tillage, furrows and raised beds, are all being tested and demonstrated individually and in various combinations. Alternate wetting and drying is now considered a mature and proven technology; IRRI's role has been one of providing the technology transfer needed to extend it out from test sites to other parts of the Philippines and beyond. Research results have given an average water saving of 20% for both deep and shallow tubewell systems, with no yield loss compared with conventional systems. Weed control is often the key constraint, so if submergence-tolerant varieties can be sown into just-flooded fields which inhibit weed growth, farmers will be saved the expense and management problems of using herbicides. The submergent-tolerant varieties being produced in collaboration with India containing this attribute should be ready for release within a year or two.

'Aerobic' rice systems in which rice is grown in wet but not saturated conditions provide even greater saving in water (of up to 40%), but result in yield loss if current lowland varieties are used. At present, aerobic rice yields are two to four tonnes/ha less than equivalent irrigated rice yields from adjacent blocks. However, in the Huang-Huai-Hai plain of Northern China, water scarcity is now so severe that ways must be found to decrease water use by rice, both in irrigated and rainfed systems. This part of Project 5 involves breeders very closely, who are engaged in developing rice varieties that can cope with fluctuating or non-saturated water conditions, and for this reason aerobic rice is a target problem for research in both Project 5 (Programme 2) and Project 7 (Programme 3). The development of aerobic rice germplasm is still in its infancy, and appropriate management systems need to be developed to cope with the range of soil environments in both irrigated and non-irrigated systems[18].

These innovations present some exciting possibilities of obtaining really significant water savings without losing the yield benefits of current irrigated rice systems, and the Panel strongly commends IRRI's contribution to these advances. A number of economic and impact studies on the benefits of water saving technologies have been undertaken by IRRI scientists

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[17] Balasubramanaian V. et al. 2003: Technology options for rice in the rice-wheat system of south Asia. Chp 6, pp115-147 *In:* ASA Special Publication 65, Improving productivity and sustainability of rice-wheat systems: issues and impacts.

[18] Bouman, B.A.M. et al. 2002. Aerobic rice (Han Dao): a new way of growing rice in water-short areas. Proceedings 12th International Soil Conservation Organization Conference, 26-31 Beijing, China. Tsughua University Press, 175-181.

and other independent researchers in recent years. These have convincingly demonstrated that AWD is providing better economic returns than full irrigation to farmers on the very large irrigated areas in China, and in areas where pumping from tube-wells provides irrigation water so reductions in pumping provide a significant saving in energy costs to farmers[19]. Savings of US$20/ha were typical in one study. This type of win-win situation offers exciting possibilities for real improvements in the sustainability of irrigated rice farming in many parts of Asia where groundwater drawdown has reached a critical situation, and farmers' profits are being eroded through the continued decline in rice prices.

The Panel considers that AWD, other water saving technologies and systems of aerobic rice production have wide implications both for farmer profits and for the governments of partner countries who are facing potential water crises in their urban supplies. However, they will clearly need a larger network of ARI scientists and water specialists to realize the opportunities offered. Such opportunities go well beyond the current initiative of the Challenge Programme for Water for Food, in which IRRI is already a lead player in association with IWMI. The two IARCs share a long history of collaboration in this area and provide a strong focus for innovative and applied research to tackle this major problem. More funding for collaboration will be needed between IRRI and the water industry science and engineering community, for example, to upscale the benefits in large irrigation scheme areas. IRRI is already a member of the International Commission on Irrigation and Drainage where national water planning and policy agencies exchange information.

IRRI has initiated the International Platform for Saving Water in Rice (IPSWAR) as a means of promoting water-saving technologies among stakeholders. This is an excellent initiative. This issue has implications beyond those of Project 5 and is therefore discussed further in Chapter 4.

The Panel commends IRRI for the work of Project 5 on economic and impact studies about the benefits from water saving technologies in different environments, and **suggests** that they use such studies to further promote these technologies in future government planning and water policies.

3.3.4 Irrigated Rice Research Consortium

The Irrigated Rice Research Consortium (IRRC) was developed in 1997 as a mechanism to promote interdisciplinary research among rice growing countries in Asia. It is supported by the Swiss Agency for Development and Cooperation (SDC) and was externally reviewed in October 2003. The review report and accompanying documentation was available to the Panel and forms the basis for this analysis. IRRI provides a structure and mechanism for partnerships with the NARS (Bangladesh, China, India, Indonesia, Myanmar, Thailand, the Philippines and Vietnam) which facilitate and strengthen research and technology delivery to irrigated rice systems.

The process is one of using workgroups formed around specific research needs that have high potential impact. Workgroup teams are interdisciplinary with a mix of research and extension workers drawn from IRRI and the collaborating NARS, who all work on the same

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[19] Moya P. et al. 2003: Comparative assessment of on-farm water-saving irrigation techniques in the Zhanghe Irrigation System. Cpt 5. Water saving irrigation for rice. Ed. Barker R, Li YH and Tuong TP. Proceedings of an International Workshop, Wuhan, 23-25 March 2001.

sites in three or more countries. Currently, the technical workgroups include those on nutrient and integrated nutrient-pest management (Reaching Toward Optimal Productivity), hybrid rice, water saving, weed ecology, and rodent ecology. The recent establishment of a post-harvest group is very welcome. Hopefully, it will encourage IRRI to direct more resources into a significant area of yield loss that has been quite overlooked. When the difference in head rice recovery between average village mill performance and good two and three-pass technology and practice can be 10-20%, this seems to be an obvious area for more appropriate village-scale development, as well as farmer and miller education. It also affords an opportunity to link production and post-production systems, and for IRRI and NARS to strengthen relationships. This Consortium provides the main delivery channel of IRRI's irrigated production systems research into the Asian region, as described earlier in this Chapter in relation to SSNM. It uses a combination of on-farm demonstration and research sites, participatory approaches, baseline and follow-up surveys, workshops and training activities to promote easy-to-use 'best practice' tools by farmers.

The IRRC review found that IRRI had been largely successful in achieving its goals in identifying and addressing regional needs in irrigated rice and in establishing collaboration and flows of information. The more challenging goals of spreading the achievements wider to more of the poor, assisting the diversification to other crops and into markets, and assisting government agencies in scaling up successful technologies for widespread adoption still remain. These issues are recommended for further work in a third phase of funding (beyond 2004). Many of these new challenges require integration of technologies across different disciplines and issues.

The review recommendations are interesting because they are precisely those that the EPMR Panel has identified as a challenge for the whole of Programme 2, if not for IRRI as a whole, reflecting the emergence of more complex mixes of public and private sector research and development in Asia, the liberation of command economies in some areas, and the emergence of significant commercialization of agricultural inputs (such as germplasm, advisory services, machinery and equipment, fertilizers and agrochemicals).

The Panel considers that this Consortium, together with its equivalent for the unfavourable environments (CURE), could grow to become the main delivery channel for nearly every product and information flow between IRRI and the NARS.

3.4. Vision and Future Objectives

Programme 2 has a vision of irrigated rice lands that can continue to provide much of the increased rice production that will be needed by an increasing world population through reduced input costs that give benefits to farmers and cheap rice to consumers. The advances of the last five to ten years in both successfully breeding for pest and disease resistance, greater yield and quality, and developing much more sustainable production systems give hope that this vision is more likely to be realized than in the past. This is an adequate 'business as usual' vision.

Today, however, there may be more cause for excitement and hope that this prospect will be realized than at any time in the past thirty years, through the dual explosions in information technology and biotechnology that have occurred in the past five years that may be captured and transformed into helping the lives of the rice dependent poor. If these new technologies are to make a difference, it should be in accelerating the pace of change in poverty alleviation through much more widespread adoption and utilization of the best irrigated rice production systems currently possible. The Panel would like to see these explicit objectives captured in Programme 2.

The Programme's vision does not include the possibility that rice will decline in importance as a crop in more affluent and productive irrigated regions. These lands are critical to the production of rice for the rapidly increasing urban population and landless, although continued declining net profitability from rice may lead farmers to change to more profitable crops where they can, as discussed in Chapter 1. Nevertheless, IRRI may benefit from developing an overall framework that identifies the most effective entry points in the whole of the rice production-consumption value chain. In particular, Programme 2 would appear to need more information on patterns of rice consumption, distribution and marketing, and the likelihood of change in the relative value of different crops in irrigated rice-based farming systems in Asia over the next five to ten years.

More detailed statistical and spatial analysis of the extent of current innovative technologies and modern varieties would also assist in closer targeting future regions and domains of special need. What is needed is information that closely identifies the areas where populations are increasing but standards of living are not. These are not confined solely to unfavourable environments, but also include irrigated areas where population densities are very high, alternative sources of employment through industrialization lacking, and poverty is endemic. IRRI should be able provide an unrivalled 'package' of technologies to assist such regions in stimulating improved rice production for poverty alleviation, and deliver these through the mechanism of the IRRC.

IRRI has already conducted estimates of yield losses that can be used to assist biotic and abiotic breeding priorities. In a large study that drew on estimates for all South and South-East Asia, the largest losses were associated with weeds, followed by insects and soil related stresses. With irrigated rice yields in farmers' fields still averaging only 3.5t/ha world wide compared with best experimental practice of 6-7 t/ha in the wet season and over 8 t/ha in the dry season, more benefit might be gained from closing the yield gap with better farmer practice, than from the spectacular yields being achieved by plant breeding that are not always applicable to more than a proportion of leading farmers in irrigated areas. In the future, Programme 2 needs to draw more from its own and external studies on the relative losses and the benefits and costs of different areas of research[20].

This information should guide priority setting among the various objectives in the three Projects that are developing and delivering rice technologies in this Programme.

3.5 Overall Assessment

In the past five years, Programme 2 has evolved from its earlier phase of prescriptive formula based solutions to rice production, to mature understanding of the complexities of sustaining and intensifying irrigated rice systems that will not fail either through environmental degradation, or through inability to provide food or profits to consumers and farmers. This is a major change in thinking, which is strongly supported by this Panel, and brings IRRI's view in line with concepts of world 'best practice' in agricultural management. It has been accompanied by a shift in delivery approach to providing farmers and advisers

[20] Evenson, R.E. et al. 1996: Rice research in Asia, progress and priorities. CAB International and IRRI.

with ‘knowledge-based’ tool kits, rather than ‘recipes’ and a suite of varieties and crop management options that allow farmers choice, even within the restrictions of relative poverty and inadequate resources.

The Panel sees this change in approach as providing the Programme with an excellent basis on which to tackle the next five years. There have been some difficult scientific challenges to address in the past five years, including the slower than expected progress with the NPT, the concern over potential and actual yield decline in intensive production environments, and the SRI diversion. IRRI’s scientists have tackled these and other more rewarding challenges with energy and rigour, and have provided effective solutions and answers.

IRRI’s irrigated rice research is soundly based on a great wealth of experimental data, able to draw on an unrivalled germplasm collection and a great depth of knowledge about the rice plant and rice production systems in Asia. IRRI has a unique position as an international collaborator that the NARS and other agencies and institutions trust and see as an impartial facilitator which provides the basis to the various networks and consortia that operate to support and improve rice-based research in Asia. This is a position that no other advanced research institute can match, where relationships inevitably are bilateral rather than multilateral as they are at IRRI. The scientific reputation of IRRI’s staff in Programme 2 is of good to excellent international standing, and its policy and commitment to free interchange of germplasm, information and training has an increasingly important role especially for poorer countries as the controls over IPR and genetic material become greater through commercial, and certain countries’, vested interests.

There are 26 IRS and PDF (post doctoral fellows) contributing in part to Programme 2, who also work in at least one other Programme. This provides good cross-cutting interaction which stimulates creativity and scientific debate. A further eleven scientists are totally committed to Programme 2, mainly in the agronomy, breeding and physiology areas who are able to keep the focus and drive needed for Project outcomes. The Panel considers this an adequate balance of time allocation. The Projects are well served in the biological and physical sciences, but have only 0.75 IRS social science/economics. The external environment in which it is now operating, and donor commitment to the broader scale issues of poverty alleviation and the environment require closer working relationships with economics and social science studies, both to demonstrate the value of its investments in irrigated rice research, and to ensure that varieties, innovative technologies and information packages are relevant to the social, cultural and financial environments to which they are applied. This issue is discussed further in Chapter 5.

The Panel **suggests** that Programme 2 strengthens its collaboration with social scientists and economists to ensure that the accelerated release of new varieties adapted to a range of biotic and abiotic stresses meet farmer and consumer acceptance for adoption into sustainable and financially rewarding farming systems.

The productivity of all Projects has been very high over the past five years, and the Panel was impressed by the dedication and commitment to achieving real improvements on the ground demonstrated by all the staff they met. The quality of the science can be assessed by the number of refereed publications, which averages nearly four per research scientist per year, higher than found in many western universities, and particularly commendable when considered against the high level of other products and communication activities (through the

IRRC and Training Centre) to which all scientists contribute, and the high demand for books, articles and newsletters published by IRRI. The Panel is impressed with these achievements and the high quality of the research work undertaken in Programme 2 over the past five years.

The work being carried out to improve the sustainability of intensive rice production systems has high potential environmental benefit as well as the real improvements that should continue to flow to poor people in terms of cheap, nutritious rice and more profitable farming. Encouraging environmental groups and international NGOs to support this work and popularize its message, not only in Asia itself, but on the world stage, would be of great added value in lifting IRRI's profile among influential sectors of the donor community. A start has been made to work with some NGOs on issues related to IPM, but could go much wider.

The Panel **suggests** that IRRI develop a closer dialogue with influential international NGOs to assist in the promotion of its win-win conservation-based water, nutrient and pest-management irrigated rice farming systems at community level.

The Panel recommends that IRRI links the work currently carried out in Project 5 with the challenge of achieving higher yields in the most intensive production systems in the context of diminishing water supplies. Further, IRRI should extend its modelling and GIS research to optimize water-saving technologies at the irrigation scheme level to provide options for water allocation.

CHAPTER 4 - IMPROVING PRODUCTIVITY AND LIVELIHOODS IN FRAGILE ENVIRONMENTS

4.1 Programme Evolution and Goals

4.1.1 Unfavourable Rice Production Systems

The fragile rice production environments consist of the less favourable rainfed lowland, flood prone and upland agro-ecosystems. Table 3.1 gives the area of production statistics. IRRI's work focused initially on improvements in the irrigated systems where plant and management production gains have been rapidly achieved, but research on fragile environments has become more extensive and more important, particularly over the last decade.

The fragile environments, accounting for 47% of the total global rice area, are characterized by the use of few resources and low and unstable yields at levels between 1and 2 t/ha. Large populations of very poor farmers (about 1 billion people in Asia) live in these environments. In these systems, the productivity of labour and land is still very low. The yield increases observed in the irrigated systems have generally not occurred in these less favourable areas. Crop failure is common and this has major implications for investment decisions by farmers in the following year.

Most rainfed lowlands are in South Asia with the major areas in Bangladesh, Cambodia, Eastern India, Laos, Myanmar, Philippines, Thailand and Vietnam. The major problems are drought or flooding in different stages of growth and low external resources inputs. However, the systems vary from favourable to very unfavourable systems. When rainfed systems are flood prone and water levels increase above 50 cm, the systems are called flood prone systems. Rice yields are generally low because of unpredictable combinations of drought and floods and problem soils. The upland rice ecosystems are located in the uplands in Asia, Africa and Latin America. Farmers in these areas generally live at the subsistence level. They are among the poorest in the world and often practice slash and burn agriculture. These systems are often degraded by population pressure and they represent a threat to forested areas.

In recent years, the attention of the international development community has focused on poverty reduction with a major emphasis on the improvements in marginal and fragile environments. In 2000 also, the CGIAR adopted poverty alleviation as its overall goal, as stated in the CGIAR Vision and Strategy. Although there is an on-going debate on whether international research investments in marginal environments are likely to create more significant impact on poverty alleviation than investments in favourable production environments, there has been an increasing tendency among the donors of international agricultural research and the IARCs and NARS to put emphasis on the fragile environments.

4.1.2 Evolution of IRRI Research on Unfavourable Areas

At IRRI, work on less favourable rice production areas started during 1970-80 with the introduction of farming systems research. This work, initiated as part of IRRI's existing programmes, involved research on upland, rainfed lowlands and the flood prone systems. This coincided with a general trend among the CGIAR's commodity Centres to start including research addressing the more complex small farmer subsistence systems in the more marginal areas that had not been reached by the Green Revolution. This trend was strengthened in the 1990s when the donors of the CGIAR called for broadening of CGIAR's goals to include NRM.

In the early 1990s, IRRI established research programmes integrating breeding and NRM activities for these specific environments: upland rice (UR), deep water and tidal wetland rice (DWR) and rainfed lowland rice (RLR). This represented the first major effort to systematically address the problems constraining rice production in the unfavourable rice systems through research. The major emphasis in all three projects (MTP) was on improving productivity through genotypic improvement and management in both the uplands and the rainfed lowlands, together with understanding the process of diversification in the uplands and reducing drudgery for women in rainfed lowlands. The objectives of the Programmes were further elaborated in the subsequent MTPs.

In 2002, following the recommendation of the 5th EPMR, these programmes were combined into a single programme, 'Improving Productivity and Livelihood for Fragile Environments', encompassing breeding (Project 7), NRM (Project 8) and the Consortium for Unfavourable Rice Environments (CURE; Project 9). The latter Project merged three separate consortia on RLR, DWR and UR. At that time, IRRI reduced its work on the deep water rice systems as little potential impact was expected from that work. That decision gets support from the Panel. In the mid 1990s, about 23% of IRRI's resources were used for research in the programmes for the fragile environments (vs. 27% allocated to the irrigated production systems). By 2003, the resources allocated to these fragile environments had gone up to 34% of total Centre resources, while the allocation to irrigated environments had dropped to 23%. Due to decreasing overall funding, this represents an annual increase of some US$2.2 M to the unfavourable systems (from 7.7 to US$9.9 M). In addition, allocation to Programmes 1 and 4 also contribute to the overall research effort for unfavourable rice systems.

In 2000, IRRI initiated work on aerobic rice systems. These systems may reduce the water use by more than a factor of two. This followed the initial work of IRRI in upland systems[21]. However, Chinese scientists (now collaborators of IRRI, e.g. Wang Hua Qi) had been working on these systems for more than a decade and developed varieties that produce lower yields in aerobic conditions than in conventional cultivation (20%), but with a 50% reduction in water use. A major research effort was lacking to explore options for favourable dryland rice production (at similar yield levels) and at IRRI a team of physiologists, breeders, soil scientists and plant pathologists started a major project on this topic. The work is located in Programme 3 as drought may occur if the rice is not flooded. Programme 2 hosts the water management research.

Programme 3 priorities have not changed in principle during the review period, although in the 2004-2006 MTP, the annual expected Project outputs are described in more detail than in the 1998-2002 MTP. The focus for the uplands, as stated in the 1998-2002 MTP, was still on drought resistance, weed competitiveness and allelopathy (although the latter was stopped in 2001 through lack of results and potential), genetic variability and host resistance of major pests, blast, weeds and nematodes, innovative breeding technologies and

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21 George T et al., 2002. Magat, a wetland semidwarf hybrid rice for high-yielding production on irrigated dryland. International Rice Research Notes. 27.1. 26-28.

more recently on the identification of P-uptake genes. For the rainfed lowlands the focus remains on drought and submergence tolerance, micronutrient enhancement, water and nutrient management, weed management and new techniques for participatory breeding. Multi-locational trials have been conducted to identify the major constraints.

4.1.3 Programme Goals

The main objective of Programme 3 is: to enhance germplasm and crop/resource management to improve productivity and human nutrition and to reduce farmers' risks in fragile environments.

The rationale of this Programme is that increases in rice production in these environments would not only improve the livelihood of the generally poor families that depend on rice for food, particularly in the uplands. Increases in rice food production would improve household food security of mainly poor people living in fragile environments, thereby freeing their resources to diversify their income generating activities. The existing technology for the irrigated environment is not directly transferable to these variable environments with adverse soil and water quality (such as salinity and alkalinity), drought, and prolonged and flash floods, which are the major constraints affecting globally 25, 16 and 20 M ha, respectively.

Programme 3 consists of three Projects. Project 7, 'Genetic Enhancement for Improving Productivity and Human Health in Fragile Environments', aims at developing improved rice varieties with higher and more stable yields, higher content of micronutrients, and more efficient water use for fragile environments. The Project budget in 2002 was US$5.44 M and the internationally recruited Project staff was 7.39 full time equivalents (FTE). Project 8, 'Natural Resource Management for Rainfed Lowland and Upland Rice Ecosystems', has a purpose of developing and providing to NARS sustainable natural resource and crop management strategies that are ecologically sound, economically efficient and socially acceptable. The Project budget in 2002 was US$4.01 M and the internationally recruited Project staff was 4.81 FTE. Project 9, 'Consortium for Unfavourable Rice Environments' (CURE), aims at developing improved unfavourable rice ecosystems with the NARS in the different rice growing countries. The Project budget in 2002 was US$0.47 M and the internationally recruited Project staff was 0.7 FTE. However, Projects 7 and 8 contribute largely to the Consortium work. So the total effort is much more.

4.2 Achievements and Impact

4.2.1 Genetic Enhancement for Improving Productivity and Human Health in Fragile Environments

The planned Project outputs, as stated in the 2004-2006 MTP, are the following:

1. superior germplasm developed for rainfed lowlands;
2. superior germplasm developed for flood-prone areas and infertile lowlands;
3. superior germplasm developed for infertile uplands;
4. aerobic rice germplasm developed for water-scarce tropical environments;
5. micronutrient-enriched rice developed to combat malnutrition in fragile environments; and
6. NARS-IRRI partnerships in rice breeding enhanced.

4.2.1.1 Germplasm Development for Rainfed Lowlands, Flood-prone Areas and Infertile Lowlands

IRRI is moving increasingly from the development of finished cultivars to the production of breeding materials, which is becoming its key role. MAS is now clearly enhancing the efficiency of this activity for a number of different traits and environments. Advances have been made. An example is the identification of a linkage map for gene sub1 for tolerance to submergence. Advances have been made in the genetic analysis of elongation, tolerance for Zn, Fe and P deficiency, but progress is needed to facilitate application into breeding programmes[22]. The role of ethylene and its manipulation in flooding tolerance has also been identified[23].

The IRRI RLR Programme has developed parental lines with important sources of stress resistance (drought, submergence and low P tolerance in combination with high yielding ability) and these are successfully used in national breeding programmes. Stress tolerant varieties, preferred by farmers, have been developed in collaboration with NARS for Thailand, the Eastern India Shuttle breeding programme, and Laos. In Eastern India, where RLR is grown in 17 M ha, 70% of the varieties are improved varieties, partly derived from this collaboration.

Cultivars were developed in the IRRI breeding programme in the Philippines and in Thailand. These have been released in several countries. In Laos, rice production increased from 1.5 M tonnes in 1990 to 2.3 M tonnes in 2001 largely resulting from wide adoption of these varieties in Laos. This major impact on rice productivity resulted in self-sufficiency in rice. The varieties are better suited for the environment than any other HYV and cover 36% of the area under RLR. In 2001, income in the households that adopted the new varieties was twice as high as in households with traditional varieties. IRRI claims an annual return on investment of 30%.

As an important part of activities in this Project, IRRI has developed methodologies for participatory plant breeding in order to ensure relevance and success of the breeding activities through obtaining farmers' feedback on varieties that have been developed. This is of course very important for the success of the breeding programme. The approach used was Participatory Varietal Selection (PVS). A manual is written on the procedures for the breeders to develop rice varieties for drought prone environments[24]. The different chapters in this manual, written by IRRI breeders, give a very clear step by step description of the breeding for drought process.

The Panel commends IRRI for the excellent progress of the RLR breeding programme in relation to new varieties that have been developed through PVS and released and is already showing impact on productivity and income. It notes that part of that impact is likely to be occurring as a consequence of research done prior to the review period, and was not yet

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[22] Gregorio, G.B et al., 2002. Progress in breeding for salinity tolerance and associated abiotic stresses in rice. Field Crops Research 76, 91-101.

[23] Ella ES et al., 2003. Functional Plant Breeding 30, 813-9.

[24] Fischer, K.S. et al. 2003. Breeding rice for drought prone environments. IRRI, Philippines. 98 pp.

observable at the time of the 5th EPMR. The activities were focused on the development of breeding materials with stress tolerance traits and on the engagement of the NARS breeders in the development of varieties that are optimal for the local conditions. These are justified in the light of the success so far. These activities are also in line with what the Panel believes to be IRRI's comparative advantage, i.e. development of parent breeding materials and collaborative breeding efforts involving the NARS.

In collaboration with the University of California Davis, IRRI has identified and mapped a major gene for *submergence* tolerance. Similar work has been done for salinity, P deficiency and Al toxicity. However, the genes associated with these traits still need to be confirmed.

Drought tolerant varieties have been identified and methods are being developed to identify genes for this trait. QTLs for drought tolerance are being identified. The heritability of reproductive stage drought tolerance was determined to be high, but so far measurable secondary traits suitable for selection have not been found. It was shown that PVS was more effective than conventional testing for enhancing adoption as farmers directly selected the varieties they prefer replacing a two step selection process. Four salt tolerant varieties were selected through PVS and released in Bangladesh and the Philippines.

4.2.1.2 Superior Germplasm for Infertile Uplands

In Eastern India and Laos, IRRI has initiated activities in an upland rice breeding network to select varieties with drought tolerance and broad adaptation, and QTLs for drought tolerance are being developed. In Northern Laos, farmer participatory research projects identified two varieties that yield over 20% more than the local check varieties[25]. The variety 'Nok' has a better quality and better yield than local checks and 'Makhinsoung' has a lower quality, but high farmer ratings. On-farm testing started in 2003. Significant production gains of up to 25% without changing inputs have been found in field trials[26]. The upland breeding programme has been suffering from the withdrawal of inputs from other advanced research institutions half way through the review period due to budget cuts, which has sadly slowed the rate of progress.

Breeding of perennial rice for lower erosion risks was planned in the 1998-2000 MTP for the uplands. Progress was made with respect to the development of crosses with intermediate yield levels and perenniality. These products have been delivered to China. This Project was deliberately ended in 2001 as management and scientists had no positive expectations from the approach compared to the alternative ways in which farmers could be helped to improve income in upland systems with reduced environmental impact. The Panel supports the decision to stop projects when confidence in their usefulness is gone.

Basically, the Project has used two strategies, one using tropical *japonicas* for problem soils and low input environments, and one with improved *indica* lines for the more favourable and more fertile upland environments for situations such as aerobic rice. Some varieties have

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[25] Linquist B. et al. Farmer participatory breeding selections for upland rainfed rice in northern Lao (in press).

[26] Witcombe, JR et al. (Eds.).2002 Breeding rainfed rice for drought-prone environments. Integrating conventional and participatory plant breeding in South and South east Asia. IRRI 94 pp.

been adopted as, for example, in Mindanao, but are spreading only slowly as the perceived advantages are small[27].

4.2.1.3 Development of Aerobic Rice Germplasm

In the last 5 years, IRRI gained interest in developing highly productive rice production systems without flood irrigation. In many tropical environments water becomes scarce and rice uses enormous amounts of water to produce grains. For a 10 t/ha (= 1 kg/m^2) rice crop 2000-4000 l per m^2 is required, while an average alternative upland crop requires 400-800 l per m^2. In non-flooded conditions rice productivity is generally much lower in tropical environments. Enormous savings of water per kg of dry matter, demonstrated in Chinese and Brazilian breeding programmes for aerobic systems, make research on aerobic rice very attractive. Aerobic rice varieties derived from improved upland indica varieties have been identified that can yield 5-6 t/ha in the dry season[28]. The step from a flooded situation to an aerobic system at field capacity costs 1 t/ha of yield. The physiological mechanisms behind this effect are being studied. The question remains why in these experiments yields in flooded situations are not higher than 6 t/ha whereas yields of around 9 t/ha are being reported from IRRI's farm. In view of the future requirements of water by competing sources, further development of aerobic rice (or high yielding dryland rice) is highly relevant as an alternative for flooded rice system. The Panel **encourages** IRRI to continue the development of highly productive aerobic rice systems with similar productivity as in flooded systems.

4.2.1.4 Development of Micronutrient-enriched Rice

Seeking solutions for combating micronutrient malnutrition is highly relevant as many health problems are related to micronutrient deficiencies commonly associated with poverty. One avenue that IRRI is following involves enhancing the micronutrient content in rice. Genes were tagged for high Fe in grains. Improved breeding lines with high Fe and Zn were distributed to the NARS partners. In a human feeding trial the effect of high Fe is now being tested together with ARIs and University of the Philippines, Los Baños. IRRI's research is well underway and IRRI is leading the crop breeding in collaboration with the Bangladesh Rice Research Institute and the Philippine Rice Research Institute (PhilRice). The relevance of biofortified crops, including micronutrient enriched rice, is recognised internationally and the Challenge Programme Harvest Plus is addressing the issue. IRRI is a crop leader for rice in this Challenge Programme.

4.2.1.5 Enhancing NARS-IRRI Partnerships

In RLR environments with highly variable environments, decentralised breeding and testing is very important. The partnerships between IRRI and NARS have been strengthened and true collaborative breeding programmes have been developed. The IRRI approach to develop and provide parent breeding materials and the identification of genes and tools to detect the genes using markers is very appropriate. The Panel commends IRRI for the

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27 Atlin GN et al., 2002. Developing and testing rice germplasm for water-saving irrigation systems. In Bouman B.A.M. et al. (eds). Water-wise rice production. Proceedings of the international workshop on water-wise rice production, 8-11 April 2002, Los Baños, Philippines. IRRI pp 275-286.

28 George T., et al., 2002: Magat, a wetland semidwarf hybrid rice for high-yielding production on irrigated dryland. International Rice Research Notes. 27.1. 26-28.

progress in developing the PVS on one hand and in the identification of major genes for water related stresses on the other hand, thereby combining an appropriate research process with scientific advancement.

Breeding work on rainfed lowland and deepwater rice was transferred to Thailand in the 1990s, but unfortunately, the Thai Government restricted the export of rice germplasm. This has created a major constraint to collaborative research and breeding. The breeding work in Thailand was transferred to the Thai national breeding programme (also because of a budget reduction at the Institute). Because of policies like this, initial analysis and identification of traits at IRRI is crucial to facilitate later exchange with other countries from IRRI as export of materials from Thailand is currently hampered.

4.2.2 Natural Resource Management for Rainfed Lowland and Upland Rice Ecosystems

The planned outputs of Project 8 include: (1) Crop and NRM practices for improved livelihood in rainfed lowlands developed and evaluated; and (2) Crop and NRM practices for improved livelihood in upland rice systems developed and evaluated. This Project brings a systems perspective in NRM research to bear with the complexities of rainfed environments where single technologies are not effective. IRRI and its NARS partners are developing farm options for farmers to draw upon.

4.2.2.1 Characterization of Environments for Research Prioritization

The major difference between irrigated and rainfed systems is that, in the latter, wide adaptation is not generally applicable. G x E interactions have been studied at the different CURE consortium sites in the past decade. Most variation was the result of the environmental component with agro-hydrology being the main determinant for this variation. The database on these experiments has value also for future research. The multi-locational work resulted in breeding priorities with respect to traits for specific environments. Different target environments were defined based on the major environmental constraint, such as late drought or early submergence. A major recent finding is that there is broader adaptation among varieties than has been expected. For example in Laos, the newly bred variety TDK1 was adapted over large and relatively diverse environments and it has boosted yields uniformly by 0.5-1 t/ha.

On the basis of the G x E studies, 8 lines adapted for the different environments were selected as probe lines in breeding programmes[29]. In a large set of multi-locational studies, nutrient requirements and opportunities to manipulate nutrient-water interactions were identified. The greatest nutrient response was to nitrogen. The work was published in a set of seminal papers that form the basis for further NRM research in rainfed lowlands.

Environments involving predominantly RLR systems were characterized and mapped with a focus on severity of drought and on identifying domains for interventions especially in Eastern India through the NARS led Environmental Analysis Network. This work is very useful for targeting new technologies.

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[29] For example: Wade, L.J. et al. 1998: Opportunities to manipulate nutrient by water interactions in rainfed lowland rice systems. Field Crops Research, 56: 93-12.

In-depth analyses were made to determine the nature of biotic and abiotic stresses and socio-economic constraints to technology adoption with respect to the toposequence, hydrology and yield relationships, shifts in weed flora and pests, changes in crop establishment methods, risk coping strategies, labour out-migration and changes in gender roles. For instance, in Bangladesh yield gap studies showed that 30% of the farmers suffer at least a 500 kg/ha (20%) yield loss due to weeds. Therefore, the Panel supports the conclusions that weed management studies must be an important component of future studies. Detailed water balance studies on regional risk for drought and zones for crop management strategies to reduce drought risks were conducted, for example, in a region in Thailand, demonstrating a very useful methodology. For rainfed rice systems in Eastern India, the economic cost of drought was estimated at US$250 M for rice and US$500 M for all crops[30]. Options to mitigate drought were investigated in a useful baseline study. Another detailed study shows that productivity growth and stability have been achieved simultaneously. However, in RLR systems in India the HYVs used were released for irrigated systems and are thus not targeted in this programme. So, yield increases must be feasible if drought tolerant varieties will be developed.

Crop diversification is an important approach for farmers to avert risk. IRRI's research shows that raising rice productivity in these environments is critical for encouraging farmers to diversify production systems for income gains. Technologies for increasing production and stabilizing yields are required in the RLR systems in India.

Socio-economic barriers to poverty alleviation such as limited access to inputs and marketing infrastructure are discussed by IRRI and NARS scientists with policy makers and more domestic resources are being allocated to R&D in various countries such as India. A study on the effect of labour out-migration, rice farming and gender roles has recently been completed to examine whether this poses a threat to agricultural production because of labour constraints. On the other hand, remittances help to generate farm household resources. As males are usually those that out-migrate, the responsibilities and activities fall frequently on the female part of the household. This has important consequences with respect to technology development.

4.2.2.2 Crop and NRM Practices in Rainfed Lowlands

The influence of the toposequence on NRM, crop performance and farmers' practices was determined and opportunities were identified to increase yield and farmers' income from rice through adjusting inputs to the position in the toposequence. For example, dry seeding of rice was a promising option for avoiding late-season drought in susceptible parts of the toposequence[31]. Experiments in Indonesia showed that yield gains of 500 kg/ha were possible through adjusting nutrient management and weed control to the water situation along the toposequence. Further activities focus on the development of simple decision tools for site specific management along the toposequence. Innovative rice technologies were introduced, such as short duration varieties and dry seeding, allowing the cultivation of a post rice crop that can use the residual moisture at the end of the season.

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[30] Pandey S. et al. 2000: Patterns of rice productivity growth in eastern India; implications for research and policy.

[31] Tuong, T.P. et al. 2000.Constraints to high yield of dry-seeded rice in the rainy season in a humid tropic environment. Plant Production Science 3,164-172.

The ecophysiological model ORYZA2000 developed at IRRI not only simulates yield potential but also actual yields in rainfed lowland and upland systems under water and N stress[32]. This work was based on the long-standing collaboration with Wageningen University. The model was well parameterized and thoroughly evaluated using multiple year datasets. The model was also adopted by the APSRU modelling group in Australia. The Panel suggests that the model be used more intensively also by the agronomists in the Programme to facilitate interdisciplinary research and conclusions.

The Project has been active in considering all phases of the production process, including proper seed storage mechanisms that influence shelf life. Such mechanisms have a large influence on germination rate, which is strongly enhanced (from 30% to 75%), and disease incidence, which can be diminished with sealed storage. Seed health techniques can also have a major impact and NGOs are promoting these practices in various regions in the Philippines.

Studies have been conducted on weed flora shifts and yield gains through more intensive weeding than farmers practice. Significant yield gains are possible, but these require additional labour[33]. IRRI's work on competitive varieties[34] is fortunately continued by the breeders in the RLR system. The varieties that are currently being tested in the field (aerobic and rainfed lowland) look very promising. Some rice varieties are strongly competitive to persistent weeds, and progress has been made in developing screening methodologies to identify these. As a result, robust models can now be used to identify traits that are required to suppress weeds. Traditional *O. glaberrima* spp. and *O. sativa: japonica* and *indica* varieties are all potential candidates. As predicted by these models, early vigour is the easiest trait to identify what really determines competitiveness.

Promising management options tailoured for specific germplasm were identified for several countries including Laos, India and Bangladesh. For example, in Bangladesh omitting insecticide use does not lead to yield loss in the T. aman crop as might be expected. In Laos, nutrient management recommendations have been developed using the Leaf Color Chart developed in the irrigated rice programme. This technology is currently being tested at the other consortium sites with promising results.

4.2.2.3 Crop and NRM Practices in Upland Rice Systems

The role of rice in improving the livelihoods of rural households was determined in upland systems through socio-economic studies. Evidence from long-term experiments that upland rice yields are declining over time when continuously cropped systems indicate the need to improve the sustainability of the system[35]. A five year experiment in central Laos has

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[32] Bouman, B.A.M et al., 2002. ORYZA2000. IRRI, 2002.

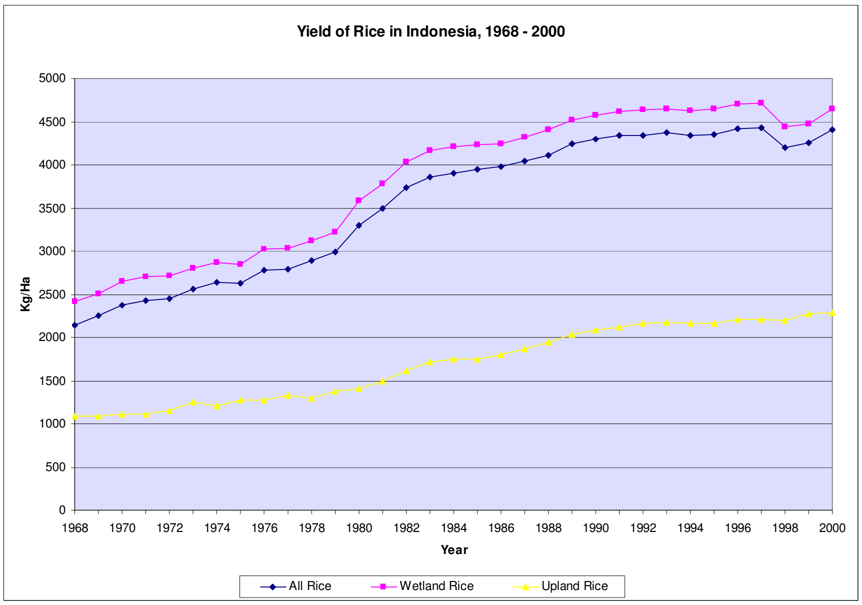
[33] Mortimer, A.M., and J. Hill, 1999: Weed species shifts in response to broad-spectrum herbicides in sub-tropical and tropical crops. Brit. Crop Prot. Council, 2:425-437.

[34] Caton, B.P. et al. 2003: Growth traits of diverse rice cultivars under severe competition: implications for screening for competitiveness. Field Crops Research 83, pp. 157-172.

[35] George T. et al. 2002: Yield decline of rice associated with successive cropping in aerobic soil, Agronomy Journal 94:981-989.

shown that upland rice yields declined from 3 to 0.5 t/ha when rice was grown every year, as a result of weed and nematode build-up, and maybe partly due to nutrient loss. There is a clear potential for improved management systems to have positive impact in upland systems. Yields have improved in the uplands in Indonesia (Figure 4.1), India and the Philippines in recent years. However, attributing these increases to specific agronomic practices is difficult. On the other hand, making improvements to traditional fallow systems (slash and burn) where legumes can be introduced into the rotation has been successful and offers many advantages. These systems are close to delivery in Laos and other parts of upland Indo-China. For example, upland rice yields increase when pigeon pea or stylosanthes are used instead of a fallow system, with the added benefit of improved household income and nutrition.

Figure 4.1 - Trends in Yield in Indonesia in Wetland Rice and Upland Rice



Experimental investigations on the mechanisms of uptake of insoluble P have also led to good breakthroughs that have allowed generalised models to be developed for upland and RLR[36]. This sound scientific knowledge can be of use in further development of the system. In China, alternative systems are explored in the hills with permanent paddy rice systems.

The new frontier project on perennial rice (for soil conservation) that was initiated in 1998 was stopped in 2001, as the project did not show real progress and opportunities for impact.

4.2.3 Consortium for Unfavourable Rice Environments

The Consortium for Unfavourable Rice Environments, CURE, is a collaborative management network in which IRRI and NARS partners identify and prioritize regional research needs, implement interdisciplinary research on the productivity, sustainability and

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[36] E.g. Kirk et al 1999: A model of phosphate solubilization by organic anion excretion from plant roots. Eur. J. Soil Sci. 50: 369-378.

diversity of rice-based rainfed cropping systems, and exchange and evaluate germplasm and technology.

In 2001, a CCER on rice research consortia for less favourable ecosystems was organized. The CCER concluded that the consortium approach had been very effective to tackle the problems in these complex upland and rainfed lowland systems. The CCER Panel concluded that significant progress had been made since 1991, but recommended that the individual consortia be consolidated and strengthened. This led to the establishment of CURE in which the work of NARS in seven participating countries now focuses on capacity building and the needs of resource poor farmers in less favourable environments. Three countries will join the consortium soon. The Panel further suggested that key areas of NARS research be strengthened, especially in the areas of socio-economic analysis, farmer participation and dissemination of results. The review recommended that IRRI's research be reorganized on an ecosystem basis and this has been done to align the work in CURE with the other Projects in Programme 3. Six working groups have been established focussing on issues of the upland and lowland rainfed ecosystems, with IRRI staff allocated to specific environments. As a result more of IRRI staff time was allocated to the fragile environment programme and more research was focused at the consortium sites. The Panel is pleased that the ADB decided to fund part of the programme for a 3 year period.

For these fragile environments consortia are essential as multiple research sites and partnerships are needed for addressing the complexities. As the fragile environments generally form a mix of uplands, rainfed lowlands and deep water rice systems along a toposequence, there is an opportunity to study these systems in partly the same locations.

IRRI's role in consortia has evolved dramatically over the past 10 years. A decade ago the consortium sites were mainly developed as research sites, each characterized by the specific conditions as required for G x E studies, for instance. NARS scientists were collaborators primarily involved in implementation. This has now changed to being a true partnership in prioritization, planning and scientific development of joint research. The added value that IRRI scientists still bring to the consortium includes their scientific input of high quality, their role in data compilation for complex G x E analyses, and their role in facilitating the exchange of information between groups. All members of the consortium who met the Panel expressed their satisfaction with the consortium approach and IRRI's approach and leadership. In the future, the value of all multi-locational datasets can be more fully exploited. Where technologies are ready for further dissemination scientists are working with reputable NGOs that have high community credibility to improve information flow.

The Panel commends IRRI for its effort and effectiveness in developing the consortium approach for integrated multi-locational research into a true partnership research system for impact with a clear role for IRRI staff.

4.2.3.1 Participation in Challenge Programmes

This programme is linked to three Challenge Programmes of the CGIAR:

1. Water and food: IRRI leads one theme and is involved in four of the twenty one projects running in the CP. In the competitive grant phase, IRRI scientists will submit proposals that will support work in this programme on unfavourable systems.

2. Harvest Plus: As mentioned, IRRI participates as the lead Centre for rice in this CP.
3. Unlocking biodiversity: This CP has a focus on drought stress for a wide range of crops. IRRI has one Sub-programme leader in this CP, which helps to ensure a link with Programme 3 as well as Programme 1.

The Panel encourages IRRI to participate strongly in these Challenge Programmes, in which it is leading major themes.

4.3 Future Objectives and Vision

The vision document prepared for this EPMR by the Programme team: *Vision for livelihood improvement in the fragile environments* shows a clear continuation of the lines of thought developed in the past decade. “IRRI’s vision is that poor people living in fragile agro-ecosystems of Asia will have enough rice to eat and will be able to improve their livelihoods through intensification and diversification of rice-based production systems, while using natural resources in environmentally sound ways. Improving and stabilizing rice productivity is a key intervention to achieve household food security, and a crucial entry point for spurring sustainable agricultural development in these fragile environments”.

The Panel supports this vision and the approaches that will be taken. However, the research programme requires a full implementation of research Projects 7 and 8 through the CURE consortium (Project 9) if it is to reach its main target for 2014 to cut drought related yield losses by 75% through the introduction of new cultivar-by-Community NRM systems. This is an ambitious objective, but current progress indicates that the targets are achievable.

The relative research contribution to the different fragile environments has changed. The effort in the RLR systems is highest as these areas are considered to have the highest potential impact from science investment and support many hundreds of millions of poor people. In deep water systems, large increases are not expected as submergence tolerant varieties exist and management of the system is nearly impossible apart from sowing system and timing and varietal choice. Other options are also becoming more attractive for farmers such as the introduction of irrigated rice in the dry season.

IRRI’s BOT indicates in its vision that IRRI should focus on the introduction of other crops than rice in the fragile environments. This will lead to an increased cash flow for the farming household. That requires a systems approach and the Panel **suggests** that IRRI carefully explore the viability of such programmes. NARS may have a comparative advantage with respect to experience in breeding and management of other (cash) crops. IRRI should provide the systems perspective and expertise on rice but IRRI has no comparative advantage for other crops. Experience has been developed in Project 11 (ecoregional approaches) and the former SARP programme with the NARS.

4.4 Overall Assessment

In the 5th EPMR, the 3 Programmes (DWR, RLR, UR) that now form the current Programme 3 were evaluated separately. The major assessment was that the time horizon for work in these systems is long and that in spite of the good science, for which the institute was commended, the achievements at that stage were very few and subsequently impact was insignificant in all ecosystems.

The Panel appreciates the strong integration of different disciplines contributing to solving the problems of the unfavourable environments. The Panel concludes that the successes discussed above brought about by the team are based upon good progress in the following areas:

- **Germplasm has been developed for the rainfed lowlands, flood prone areas and uplands. Finalized varieties were developed and released and breeding material was generated and used in PVS programmes at different locations in the CURE consortium. At the genetic level, markers for genes were identified for tolerance for stresses such as submergence, salinity, drought, P deficiency. Also, micronutrient enriched germplasm was developed. Aerobic rice germplasm was identified for the more favourable environments with the potential of high yields using less water, but further improvement is needed.**
- **In the NRM programme, environments were characterized for research prioritization and better understanding of G x E interactions. Target environments were defined for specific variety types. The nature of different stresses was identified. Sound G x E studies were conducted. However, performance of a wide range of genotypes increased in later studies.**
- **Management systems were developed for the different environments. A simulation model was further developed (ORYZA 2000) and used to understand crop performance at different locations and positions along the toposequence. Special attention is paid to weed management.**

In the Panel's judgement, the science in the Programme is of good quality although not all major achievements have been published in refereed journal articles yet. Much of the key information mentioned is published in IRRI books or proceedings. Much of the agronomy and soils research has been published in high ranking international journals. Regarding impact studies, refereed journal papers would help to strengthen the cause of the Institute as a key node in the rice science network.

In spite of the difficulty in improving these unfavourable systems through research, and particularly in scaling up research results, examples are now available that show progress towards achieving impact in these environments. The Programme had a strong impact especially in the rainfed lowlands of Myanmar, Cambodia, Laos, Eastern India and Indonesia, as can be seen from increasing yields in RLR and UR ecosystems shown in the example from Indonesia (Figure 4.1). In recent years, HYVs selected by farmers with proper traits for the specific environments have been adopted and, in some cases, led to impact at household income level. In some countries such as in Laos, Myanmar and Cambodia, which are characterized by young research and extensions systems, rice research programmes led by IRRI have led to major increases in rice production. In Myanmar, IRRI's relatively modest research investment has resulted in 100% yield increases. These translate into US$400 M increased returns from rice production. Similar yield increases have been documented in the rainfed lowlands in Eastern India where there is potential to reach very large numbers of poor people. As a result of HYVs mainly, yields have increased 9.5% since early 1990s and are more stable. These yield increases when scaled out over a very large area, are significant and a major potential for further increases remains. The Panel acknowledges the progress made both in terms of achievements and emerging impact in people's livelihoods over the review period. In the upland programme, tropical *japonicas* are now being developed for problem soils, but it is too early for broad adoption and impact is still not shown.

Current results are promising and IRRI needs to document progress towards impact very carefully in spite of the difficulty in linking the contribution of research to productivity increase, especially with respect to NRM. This deals with the impact of research on productivity, and in the end on the livelihoods of people. The Panel thinks that most impact can be generated in the RLR systems and in aerobic rice systems or better said non-flooded high yielding rice ecosystems. The term aerobic does not really appeal.

The Panel commends IRRI for the high quality science in this Programme that led to improved insight in water, nutrient and pest management and improved varieties. The Panel also commends IRRI for achieving impact, in the past 5 years, in these complex systems which are inhabited mostly by poor people.

The Panel supports further development of the research programme as one which is owned by a group of institutions, of which IRRI is one. The consortium approach has shown to be very successful as a mechanism that is not only appropriate from an ecological point of view in these variable environments, but also for developing equal partnerships between IRRI and NARS scientists. Each working group needs an IRRI IRS in the coordinating team as (co) leader because IRRI, as an impartial organization, is well equipped to work across several countries and many locations. It is very important that IRRI further develops participatory approaches with the NARS to facilitate dissemination of technologies. Training, already a strong component in special projects and through CURE, will be even more important in such a model, as most NARS do not yet have a critical mass of scientists devoted to working in unfavourable environments.

The Panel recommends that IRRI include the results of *ex ante* impact studies in unfavourable environments in its priority setting exercises. The existing evidence indicates that less emphasis should be placed on uplands with low production potential and more emphasis is needed on rice-based cropping systems along the toposequence and favourable non-flooded rice systems.

CHAPTER 5 - STRENGTHENING THE LINKAGES BETWEEN RESEARCH AND DEVELOPMENT

5.1 Programme Overview

Programme 4 is a successor of the old 'Cross-Ecosystems Programme' (CEP). It combines three social science Projects of the old Programme. It also includes most elements of the 'Accelerating the Impact of the Rice Research Programme', including training and individual country projects.

Previous work on increasing productivity by adding value to rice and reducing drudgery of farm labour was partly curtailed and partly transferred to Programme 2.

Currently the Programme has three Projects. Project 10, 'Understanding Rural Livelihood Systems for Rice Research Prioritization and Impact Assessment', combines two earlier projects from the CEP. Project 11, 'Enhancing Ecological Sustainability and Improving Livelihoods through Ecoregional Approaches to Integrated Natural Resource Management', evolved from the older CE-6 project, 'Implementing Ecoregional Approaches to Improve Natural Resource Management in Asia'. The origin of this work is in the Systemwide Ecoregional Initiative launched by the CGIAR in the early 1990s. For the Asian humid and sub-humid tropics, IRRI was chosen as the convening Centre. Project 12, 'Facilitating Rice Research for Impact', combines several earlier projects and includes work on developing decision-support systems for knowledge and knowledge-intensive farming systems.

Table 5.1 indicates the financial vicissitudes of these three Projects (and their predecessors) back to 1998. The data suggest high variability in all these Projects against a background of long-term decline in aggregate funding for IRRI. The variability is to be expected, given the larger role that special project funding plays in these activities, although it must be said that Project 10 has been better protected against the general decline in funding than the other Projects.

A first glance at the Project descriptions suggest that this Programme is residual to everything that IRRI should be doing but which is not done in any other Programme. The stated mission of the Programme is to bridge the gap between generation and dissemination of technologies and bring farmers' perspectives into research planning for improving research relevance and fast tracking of impact. While this encompasses the activities that are currently undertaken in this Programme adequately enough, it appears to have been written after the individual Projects were somehow gathered into the Programme. Had this been written before the Programme was created, it would have been too diffuse to provide an indication as to where the Programme should be heading, and what projects to embark upon.

A more coherent presentation can be made if we separate the Programme into two parts, one consisting of Projects 10 and 11, and the other part being Project 12, each of which has its own rationale. It so happens that each part is closely identified with the work of a particular Division – Social Sciences in the case of Projects 10 (wholly) and 11 (mostly), and International Programs Management Office (IPMO) for Project 12. Therefore, the following assessment of the Programme is bound up with the assessment of the Divisions concerned and includes three sections: Social Science Projects covering Projects 10 and 11, Social Sciences at IRRI discussing social science beyond Programme 4, and Training and Country Programmes dealing with Project 12, ending up with a section on Conclusions.

Table 5.1 - Budgeted and Actual Expenditures[1] on the Direct Costs[2] of Projects in Programme 4 (and their Predecessors), 1998-2004

Year	Project 10[3]		Project 11[4]		Project 12[5]		IRRI	
	Budgeted	Actual	Budgeted	Actual	Budgeted	Actual	Budgeted	Actual
1998	898	662	744	547	7,605	6,412	37,763	34,790
1999	993	673	969	510	7511	6,388	37,512	35,105
2000	1,170	1.086	622	447	7,785	6,409	36,795	32,605
2001	985	908	802	860	5,673	5,019	35,875	32,642
2002	1,111	703	958	937	5,791	5,168	32,237	32,040
2003	1,055	706	468	460	6,021	5,277	32,533	28,677
2004	765	n.a.	383	n.a.	4,083	n.a.	31,430	n.a.

[1] Thousand US$.
[2] Direct costs include the cost of Project implementation such as salaries and benefits of Project staff and related general operating costs.
[3] Before 2002 equals the sum of CE-5 and Rl-1.
[4] Before 2002 equals CE-6.
[5] Before 2002 equals the sum of CE-4, RL-5, IM-1, IM-2 and IM-4 including Country Projects.
Source: IRRI, Administration and Finance.

5.2 Social Science Projects

5.2.1 Understanding Rural Livelihood Systems

5.2.1.1 Achievements

The planned outputs for Project 10 are: (1) Rice-sector analysis conducted and rice statistics database maintained and shared with NARS; (2) Rural livelihood systems studied and the interaction among technology, infrastructure, and institutions analysed; (3) Constraints to adoption of improved rice technologies assessed; and (4) Impact of rice research on poverty alleviation and sustainable management of natural resources assessed.

Project 10 covers many facets of the social sciences activities, and it is best to divide the outputs of this Project into two broad groups. In the first group, the Social Sciences Division, the primary owner of this Project, serves the rice research community, both within and outside of IRRI, by providing database and useful analysis of the economics of new technology. In the second group, the users of the output are other social science researchers or policy makers. The borderline between these two groups is not sharply defined but the division provides a useful way to proceed with the discussion.

Falling squarely within the first group is the analysis of the constraints to and impact of new technologies. In the case of impact analysis, the Project team has embarked on an *ex ante* analysis of the introduction of hybrid rice in Tamil Nadu, India, and found that the undoubted yield advantage is neutralized by the lower price fetched by hybrid rice because of its lower quality. The work was later expanded to cover five countries, and the results confirmed. This was conveyed to breeders working on hybrid rice, and quality was given a higher priority among the breeding objectives.

In another *ex ante* analysis of the impact of stress tolerance, the researchers estimate yield losses due to insects, diseases and abiotic stresses by soliciting the perceptions of researchers, extension workers and farmers, and arrive at the conclusion that drought, submergence and weeds cause more losses than insects and diseases. Stated thus baldly, the results may not appear surprising, but the quantification is important and can lead to further analysis and be used in allocating research resources. More specifically, among the diseases, bacterial leaf blight and blast were identified as the major causes of yield loss, ahead of tungro virus, which had been given priority in IRRI. As a result of this work, there was an adjustment of the Institute’s priorities. Furthermore, the results of the work have been utilized by IRRI to justify investments in particular activities when submitting proposals to donors.

Ex post analysis of the impact of IRRI’s contribution to varietal improvement research was also completed as part of an overall study by the Standing Panel on Impact Assessment (TAC CGIAR). The study traces the genealogies of the varieties released by IRRI and by the NARS, and shows that IRRI’s contribution remains quantifiably significant: even though most of the later releases have come from the NARS, they have as their ancestors an IRRI line.

A case study[37] of the impact of rice research on poverty alleviation in Bangladesh was conducted and indicates that while the poor, who are mostly landless, benefit little directly from rice research, they benefit substantially from the availability of year-round employment and agricultural growth induced rural non-farm activities, as well as from lower rice prices. These findings were made available to the policy makers and civil society groups, through a series of policy dialogues, supported by an externally funded Project called ‘Poverty Elimination through Rice Research Assistance’ (PETRRA). The Dhaka-based Centre for Policy Dialogue invited senior government officials, university teachers and other elites to six dialogues, whose topics include, among others: agriculture’s role in poverty alleviation and strategies and policies to support rural non-farm activities.

This last study shades into the second group of research outputs of Project 10, in which the major users are the broader community of social science researchers and policy makers. The first, which a rice research institute must keep a careful watch over, is the balance of world rice supply and demand. In this respect, IRRI piggybacked on the continuing work at IFPRI which models supply and demand of all agricultural commodities. As the rice model depends on accurate and up-to-date estimates of the various parameters used in the model, it engaged in detailed studies of a number of Asian countries, with special emphasis on rice. These studies have been gathered into a volume entitled *Developments in the Asian Rice Economy,* published by IRRI in 2002. Since then, staff commitment to this part of the Project has been cut.

Rice sector work is not only confined to this modelling exercise, but extends to other policy issues. A work in progress concerns trade liberalization in the Philippines, funded by the Philippines Government. A paper from this Project shows that while that country has

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[37] Hossain, M. et al. 2003: Rice research, technological progress and impacts on the poor. IFPRI Discussion Paper 110. Washington DC: International Food Policy Research Institute.

made great progress in increasing rice yields during the Green Revolution, and has brought domestic prices down considerably, those prices have remained static since about 1980 at about the same level as world prices in that year[38]. Since then world prices have continued to decline. Maintaining domestic prices above world prices through import controls after 1980 merely further impoverishes the Filipino poor who are mostly from rice-deficit households.

At the microeconomic level, Project 10 examines rural livelihoods. Here IRRI, in partnerships with social scientists in the various NARS and capitalizing on data previously collected by IRRI, went to the same households that were drawn upon in the earlier sample survey to collect the current year's data, to obtain what are known as panel data. One conclusion that has clearly emerged is the diminished role of rice in the incomes of most households as non-farm activities came to provide more and more of household income, and increased income inequality because the distribution of non-farm incomes is more skewed than the distribution of farm incomes. The generation of primary panel data of this kind cannot but be useful to researchers everywhere, and it is to be hoped that IRRI will be able to make them easily accessible.

Another activity is to use GIS to generate a poverty map of Bangladesh, which combines socio-economic data from the aforementioned inquiry into the impact of rice research with bio-physical and climatic data at sub-district levels (an average sub-district in Bangladesh would have about a quarter of a million people). The cross-linking of these data by using GIS is used to uncover relationships which explain household income levels, and that better explain poverty, and thus provide useful policy guidelines. The preliminary results were presented at a workshop attended by a member of the Planning Commission and staff from the Ministry of Agriculture.

5.2.1.2 Assessment

Project 10 is somewhat sprawling. Each of the four outputs expected of the Project is worth pursuing and reaches satisfying results, but they are all quite different and show little possibilities of synergy, except perhaps between Output 3 ('Constraints to adoption') and Output 4 ('Impact of rice research'). The main concern is whether the resources (scientific, financial and managerial) of the Project are being spread too thinly. On the scientific management side, the Programme successfully supplements its resources by drawing from other research institutions: for example, IFPRI on rice supply/demand analysis in Project 10; and with the Economic Growth Centre, Yale University on the impact of germplasm enhancement also in Project 10. Nevertheless, the fact remains that the Project remains amorphous in terms of purposes and objectives.

Discussion of how to tackle this problem will have to wait until we examine the role of social sciences in IRRI in the following section. For the moment, what can be proposed is the elimination of the work done on rice sector analysis (except for the rice database and the compilation of the World Rice Statistics). Much of the rice sector analysis can be best done at IFPRI, or by economists at Asian universities. Nonetheless, IRRI economists should maintain

[38] Dawe, D. 2002: Equity effects of rice trade liberalization in the Philippines. *In:* T.W. Mew, D.S. Brar, S. Peng and B. Hardy (eds.): Rice science: innovation and impact for livelihood. Proceedings of the International Rice Research Conference, 16-19 September 2002. Beijing (China): IRRI, Chinese Academy of Engineering and Chinese Academy of Agricultural Sciences.

watch on work done in this area as background to their work, and at least one person in the Division should have skills in this area.

5.2.2 Enhancing Ecological Sustainability and Improving Livelihoods

5.2.2.1 Achievements

The expected output of Project 11 is 'the ecoregional concept for INRM adopted and systems approaches applied for improving livelihoods and sustaining natural resources'.

At first sight, the Project appears overly ambitious, aiming as it does "to improve livelihoods of rural communities by enhancing the sustainability of their supporting socio-ecological systems". What makes the Project manageable is the common method of analysis it employs to answer a wide array of questions. The Project employs a systems perspective, and builds upon extant NRM research at the farm or field level, and then brings in additional tools (e.g. GIS) to model and analyse interactions at higher levels of biological, physical and social organization. It thus uses a model developed with the Wageningen University to explore scenarios of resource use and determine trade-offs between objectives. Based on such modelling, multiple-scale and multiple-stakeholder approaches were then implemented in three pilot regions for INRM.

One successful activity provides a glimpse into how such exercises can be translated into policies. One of the test sites happened to be in the Mekong River Delta, where the Government took it to be its task to control saline water intrusion during the dry season in order to promote the expansion of rice production. But this adversely affected the livelihoods of fishers and shrimp farmers, who breached embankments to let saline water into their ponds. Since the pilot study area was nearby, a multi-disciplinary team of researchers from IRRI, IWMI, universities in Vietnam and the UK studied the impact of water policies in Mekong River Delta, and the systems framework of the Project was ideally suited for such difficult policy choices, involving the trade-off between rice production and income from shrimp farming and fisheries. The Government had by now realized that its policy to maximize rice production was not working, but what was missing was the design of a new policy to replace the old one. The Project was able to articulate a new policy that had a clear technical backing, but dependent on data and judgments provided by local stakeholders. This convinced the Government of Vietnam, which quickly implemented the new policy.

In another test site in Northern Vietnam, the Project aims to improve the food security of the minority ethnic groups while ensuring sustainability in agricultural production and natural resource base of the fragile environment. The site is obviously complex, both bio-physically and socio-economically. The Project capitalized on and mobilized the knowledge extant in the area, and seriously attempted to scale up location specific studies. While there is no simple 'technology package' to deliver to the farmers of the area, it enables them to do something more important: it allows mutual social learning, whereby the interactions it elicits among stakeholders provide better insight into the local social dynamics.

5.2.2.2 Assessment

When IRRI was asked by the CGIAR to convene research employing the ecoregional approach on the Asian humid and sub-humid tropics, it accepted the task somewhat reluctantly, as it did not wish to venture much outside its focus on rice. But having accepted it, it went about the task systematically and deliberately, with the focus on knowledge building and testing out models of interactions at different levels of biological, physical, and social organization. Project 11 is the result, and its output has had clear impact in specific locations, such as the problems faced by the Vietnamese authorities with rice farmers as against fishers and shrimp farms on water and land use in the Mekong Delta as described above. Just as important, it shows how work on integrated NRM should be done, combining as it does, the ‘soft’ but nonetheless necessary participatory approach with the ‘hard’ mathematical modelling and computer simulation. Finally, the Project is one of the few in IRRI where it ventures into areas where non-rice crops are important. Indeed, in the Mekong Delta case, IRRI ironically ends up proposing a policy that would reduce rice production in an area that is otherwise ideal for rice production.

Given the excellent work that is being done in this Project and its sister Project 8, it is a pity that resources are being more constrained, as employment rules and general staff cuts necessitated the departure of a very capable IRF. With this departure, work of this nature has been curtailed because of low IRS time allocation. Fortunately, an important component of this Project is the transfer of technology to national research groups, and it is hoped that they will continue the good work initiated in collaboration with IRRI. Yet IRRI’s management has to carefully consider the usefulness of this type of ecoregional work in its own work in its two production Programmes.

In line with this thinking, it is perhaps best that this Project be housed in the production Programmes. Currently, the Project Leader also heads Project 8 in Programme 3, with which there is a clear overlap, and there are obvious benefits from a merger of the two Projects. However, Programme 2 will also benefit from the kind of work done in Project 11. IRRI’s management can then base its decision on whether to put more resources into the GIS unit that is in charge of this work by seeing whether there is a major demand from the two production Programmes.

5.3 Social Sciences in IRRI

The Social Sciences Division has had a distinguished record of productively contributing to the work of the natural scientists in IRRI, even in the earlier period when IRRI had a single-minded concentration on increasing yields, and the contribution of social scientists to ongoing research might have appeared superfluous. Now that IRRI is pursuing more complex goals, social scientists’ contributions are more crucial than ever.

The quality of social science work in IRRI can be rated as fairly high, but with some heterogeneity. In coming to this judgement, the Panel considered not only the output from Programme 4 (both in terms of published work, and in their interactions with NARS’ researchers), but also the Division’s contributions to other Programmes. The Panel also heard the expressed need from the production Programme leaders for more social scientists’ input into their Programmes’ work.

Social scientists can contribute to the work of the Institute at three stages. The first stage is during the formulation of a project or subprojects. At that point they need to work with Project Leaders, use their own analytical tools to estimate the benefits and costs of the project or task, the probability of its successful fruition as a scientific project and the probability of its product being adopted. This will also help the management’s prioritization task.

The second stage is during the project or task implementation. At this point, social scientists provide a feasibility check while the project is going on, to see what constrains the farmers from adopting the evolving technologies. At the same time, where the task involves working with farmers or their communities in participatory research, social scientists' contribution is also needed to map out the interaction process, to design the methods of collaboration, and then to define the characteristics of the interventions. Equally importantly, at any time during this stage, it may be the case that the task is no longer worth accomplishing, either because the research is going nowhere, which is what the scientists themselves could realize, or – and this is where social scientists are needed – because external developments in the rice market or the input markets may drastically reduce the benefits of the project.

The final stage, once the task is completed and assuming it to be successful, is for the social scientists to evaluate the impact of the technology generated in increasing the well-being of people affected.

Social sciences' work would more effectively improve the Institute's output if it is drawn upon to participate from the very beginning of the project and continues until after the project is completed. This does not imply that the same scientist be assigned to a given task throughout its life, rather the opposite. Organizationally, the Social Sciences Division will implement the first and third stages of the task cycle. At the same time, it will supply social scientists to work in the two production Programmes during the second stage.

In terms of the current Projects, Project 11 will then become part of the two production Programmes. As for Project 10, the Panel has already suggested that the rice sector analysis component be de-emphasized (except for the statistical database). The constraints component would be in the second stage of the task cycle and therefore should be housed in the two production Programmes, while the impact component would be the third stage of the task cycle, and would therefore remain in the Social Sciences Division. This would leave the extremely useful rural livelihoods Project unaccounted for. The Social Sciences Division should still conduct this last component because, after all, it provides valuable data resources for both the first and the third stages of the task cycle. In this picture, the Social Sciences Division will still be conducting substantive research (although whether all this research should be placed together into something called a Project or Programme is just a matter of nomenclature).

But what the Panel is proposing is more than mere adjustments to Project 10, where the constraints and impact work applies to a small subset of projects and activities carried out in the Institute. What is being proposed here is a more integral role by social scientists to help in prioritizing the projects so as to maximize adoption and people's welfare. The Panel recognizes that the current level of resources available for social sciences work is inadequate, but leaves it to IRRI to work out how much of the greater scope of that work will be met by additional resources, and how much by a realignment of the personnel within the Social Sciences Division.

5.4 Training and Country Offices

According to the Project title and goal, Project 12 facilitates rice research for impact by building national research and delivery capacities and validating the products of research with target group farmers.

The purpose of Project 12 is to bridge the gap between technological production and technological use. Dissemination of improved technologies that will reduce drudgery, raise incomes and protect the environment across hundreds of millions of rice farmers in Asia is an immense task requiring the cooperation of many NARS partners, advanced institutions, and non-government organizations. IRRI sees its role in this process as threefold:

- to improve national capacities in problem identification and knowledge transfer;
- to improve farming systems through participatory approaches to validate and adopt knowledge-intensive farming systems; and
- to assist NARS in developing better focussed, high quality national research.

Project 12 operates across all other Projects in IRRI, providing the framework to deliver knowledge and technologies generated elsewhere into national and provincial research and extension agencies. To be effective, the Project personnel must collaborate closely with those in all other IRRI Projects that have deliverable outputs, and particularly through the Consortia, as well as establishing and maintaining strong ties with IRRI's representatives and immediate institutional collaborators in each partner country. Internal and external institutional relationships are currently being evaluated and redirected to enhance delivery efficiency. This has required a review of the existing operations in training and capacity building, and a review of IRRI's interactions with different rice producing countries around the world. Consideration is given to present research capacity, level of activity with IRRI (including whether IRRI maintains an office or staff with them, or collaborative arrangements), and the level of support that IRRI can be reasonably expected to provide to requests for assistance[39].

IRRI's headquarters' location within the University of the Philippines Los Baños, in which many IRS staff are affiliated Faculty members, has always provided the ideal opportunity for the teaching and supervision of graduates drawn from many nationalities. Short courses have also been a long-standing feature at IRRI, carried out in its own Training Centre. Some of these training activities are now changing as the result of changes in the external environments of partner countries.

IRRI has always committed itself to training up a cadre of rice researchers since its inception, which now form a strong network of alumni, who amplify the work of germplasm and information dissemination to a far greater extent than would otherwise be possible, given the relatively small number of staff available in IRRI itself at any one time. Over the past forty years IRRI has trained more than 14,000 rice scientists through this process. During the 1991-2002 decade 403 people received post graduate degrees (MSc and PhDs) and 493 came as on-the-job trainees for further skills development. An additional 1,631 participated in short courses of a week to a month's duration on specific topics. Over 90% came from Asia, and more than a quarter were women.

In addition, many thousands of farmers and hundreds of extension workers are involved in participatory learning processes in their own countries through IRRI's work in special projects on capacity building, the activities of the Consortia, and a range of

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[39] Bell, M.A. et al. 2000: Research for Development: IRRI's In-Country Roles. IRRI Discussion Paper Series. No. 41. Makati City (Philippines): International Rice Research Institute. 30 pp.

information-dissemination initiatives. The pro-active encouragement of women includes offering a special training course for women in leadership, drawing women from a wide range of national institutions. The Panel commends this initiative, especially important for a crop in which so much of the labour force is female and research objectives are gender applicable. Many of the senior research staff in national research institutions, such as Cuu Long Delta Rice Research Institute and the Bangladesh Rice Research Institute, received their graduate training through this route.

While scholars enrolled for higher degrees with universities with which IRRI has formal agreements have continued to come to IRRI to conduct their research, intake is currently 50% less than at the beginning of the last decade. The number of on-the-job trainees has also fallen but to a lesser extent, whereas participants in regularly offered short-term group courses have risen recently. This reflects the pressures now being placed on national staff to be away only for short periods, at lesser overall cost to their agencies. On the other hand, there are many other increased opportunities for training, knowledge and capacity building that are replacing this form of training.

Many externally funded projects have specific capacity building components built into them, such as the major investment by the Swiss Development Commission in Laos, where, over three five-year phases, a complete research capacity in rice production has been developed, including training of national research and extension staff, as well as the establishment of national germplasm, varietal evaluation and production systems testing. In the PETTRA project a total of 27,000 training days were conducted in 2003. Such capacity building projects draw resource material from IRRI, and may support graduate students to work at IRRI, but are less financially dependent on the resources available through IRRI in-house training than those projects supported through core and restricted core funding. IRS IRRI staff took part in 8,000 training days across the region and 12,000 training days at IRRI. Taken together, these statistics represent a very large investment in time and effort on the part of all those committed to improving rice productivity and this is impressive.

The massive revolution in information exchange and knowledge systems that has accompanied the development of the Internet and telecommunications in the past five years has provided new opportunities for IRRI to achieve its training and information dissemination objectives, and perhaps to overcome some of these restrictions. At the same time, some of IRRI's traditional national partners are maturing to become such significant research collaborators in their own right, and no longer require the same level of capacity building assistance, with the result that more resources can be channelled into countries that have less capacity.

In 1999, IRRI hosted a meeting to consider the potential for Information Computing Technologies (ICT)[40] in extending new knowledge systems for rice faster to a much wider audience, assess the value of distance education and assist in direct ICT training. IRRI's vision translated into developing a 'rice-knowledge centre without walls', using a high speed, high bandwidth node on late generation internet. This has required substantial investment to support the new technologies and a dedicated group of professionals committed to maintaining and constantly upgrading the service. However, compilation of resource material and delivery of specialist subject matter still rely on the continued contribution of IRRI

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40 Raab, R.T. 1999: Report on the think tank meeting on the use of ICT to support IRRI's training and information dissemination services. Occasional Papers: Issues in Training. Paper1.

scientists from across the whole organization. This ensures that there is continuously relevant material and close quality assurance of information that is packaged into easy-to-use ‘tools’ for practitioners. Two decision support tools have already been developed - ‘Rice Doctor’ and ‘TropRice’. These have been highly popular, providing practitioners with immediate sources of information via the net, and a back-up set of hard-copy pamphlets, further sources of information and other linkages.

The Rice Knowledge Bank has been a major product from this initiative, with both CD and on-line products, much of it being regularly upgraded, and with translations into all major Asian languages. Co-development with NARS users and a wide range of strategic partner organizations ensures that information is tailored to local conditions and needs, using a wide range of technology options to ensure that less advantaged clients can access the new products. This is a major achievement of enormous consequences, and the Panel was enthusiastic about its potential for speeding up the acquisition of improved farming systems, more in-depth knowledge and greater food security in rice everywhere.

Future developments already in the pipeline or planned for this concept include collaboration with the World Health Organization (WHO) providing their information sources on health and disease in rice growing areas through this portal, and collaboration with the World Fish Centre and other institutions on Rice-Fish systems. Experience at IRRI has shown that eLearning (distance education by web processes) is not the way to go at present. Courses that have been conducted by internet and course materials alone are not so successful, and have less participant satisfaction than courses that blend person-to-person contact with small packages of well targeted knowledge on client specific topics. IRRI has a head start in this area and its experience should be drawn upon in developing models for future IT-learning developments across the CGIAR as a whole. The CGIAR Learning Resources Centre developed by ICRAF and IRRI is a case in point, where IRRI’s role in providing lessons learnt, input on technical issues and optimization of the system of delivery has been very useful.

It is hard to overstress the importance of this development, and IRRI’s commitment to free and open distribution of rice knowledge through a wide variety of distribution channels. The Panel sees this as an area of expanding need in the future, as the pace of biotechnology information speeds up and the increasing complexities of rice system management places increasing knowledge demands on research and extension personnel as well as on farmers everywhere. Without the adequate capture, interpretation and translation of this knowledge into locale specific and relevant forms of communication, much of the value of the advanced science in rice that is currently blossoming around the world will not have benefit in the rice farming communities.

The Panel considers that Project 12 falls into a special category that should justify the creation of a separate cross-cutting service unit, rather than being considered as a part of Programme where the majority of other work concerns socio-economic issues, including economic evaluations, ecosystem characterization and impact studies. In the future, if IRRI increasingly adopts the role of information and technology facilitator between the advanced research institutes and clients in rice-growing regions, the task for this Project will expand greatly and resources will need to be diverted from conventional areas of scientific research in IRRI to support its expanded role.

Already, the Training Centre is one area that has strong links with countries in Africa (particularly Madagascar and Tanzania), and in the future demand for rice knowledge systems from African countries may increase. Similarly, there are rice producing countries in the first world with which IRRI maintains a range of linkages in research collaboration. With the current very high level of research activity that is being devoted to rice biotechnology in some of these countries, it is probable that the volume of information that will need to be analysed and 'repackaged' for client users in Asia and Africa will also increase rapidly in the next five years, requiring expansion in the Training Centre to accommodate this. The Panel **suggests** that budget allocations within all Projects more clearly specify their needs for training in the future, so that their responsibilities and roles in capacity building can be more clearly identified internally and by IRRI's clients.

5.5 Conclusions

This Chapter examines the work carried out by the Social Sciences Division and the IPMO. The Panel considers that relevant and high quality work is being done in each of the three Projects. The main thrust of the Panel comments concerns the role that these two Units play in the Institute, and the dissatisfaction that the Panel feels in seeing their work placed alongside all the research Projects.

The Panel would like to see the work of social scientists at IRRI being expanded into an involvement with every major task at its beginning to examine whether its benefits exceed its cost, and also to weigh the probabilities of its success and its adoption. During its execution, social scientists are needed to consider the constraints limiting farmers' adoption, and also whether the task should be terminated or redirected. Should the project or task be carried on through to its completion, and assuming it to be successful, social scientists are needed to evaluate its impact on the well-being of affected households. Such an expansion in the role would imply that IRRI expands the role of social science substantially.

Similarly, training in IRRI should not be treated just as another project. Its activities already spread across the full extent of the research Projects, which have constant interaction with its functions in providing information to the Rice Knowledge Bank and its contributions to training modules. The Panel envisages an increase in the prominence of the whole of the knowledge delivery activities in IRRI in the future. IRRI's experience and lead in packaging knowledge and delivering it through the Rice Knowledge Bank, for example, can provide a model for other initiatives in the CGIAR. The 'Training' centre will be better viewed as a cross-institute programme that contributes to the delivery of the research output.

Both of the observations pertaining to social science work and to training imply that Programme 4 as it stands should cease to exist.

> **The Panel recommends that activities on 'Constraints to adoption of improved rice technologies assessed' in Project 10 and the entire Project 11 be transferred to Programmes 2 and 3, while the rest of the activities in Project 10 be done in a new stand-alone Project, with Programme 4 being dissolved.**

CHAPTER 6 – SCIENCE QUALITY AND PARTNERSHIPS

6.1 Introduction

In this Chapter the Panel assesses the quality of the science and the partnerships IRRI has with ARIs, NARS and other stakeholders, that are all needed to be effective.

In any modern organization, strategic planning, priority setting and resource allocation require an analysis of the target area in which the organization expects to have impact, in order to define where its interventions will have the greatest pay-off for investment. The Panel considers that IRRI has the capacity to undertake these analyses systematically for all operational planning through the Social Sciences Division, as proposed in Chapter 5. Similarly, IRRI's impact assessment studies help the on-going adjustment of research activities to achieve maximum benefit. To assure that research is conducted in the most efficient way and is of high quality, the Centre has various mechanisms that it can use systematically at scientist, Project and Division level. These activities, together with the documentation IRRI maintains on publications and other research outputs, provide the basis for a comprehensive evaluation of quality of the work undertaken in the Centre.

As a mission oriented organization, IRRI constantly checks the relevance of its work against the context of the world in which it operates. As noted in Chapter 1, this world is changing fast. The pace of science and technology has accelerated, and the growth and complexity of the economies of the rice producing countries in Asia have increased in the past five years. The demands on IRRI could easily lead to it becoming all things to all people and losing focus. These changes also challenge IRRI's identity and function, with the need for regular review and recurrent articulation. IRRI is helped in this process through its close operating partnerships with a wide range of organizations, both among rice producing countries and at the international level. These relationships are crucial to the successful and effective delivery of its mission.

6.2 Research Quality Assessment

In the Programme Chapters we have assessed the relevance of the research activities and the quality of the Project outputs. In this Chapter we discuss scientific standards of research staff and the processes in place for enhancing quality. We also discuss IRRI's linkages to the outside world that are needed for producing relevant research outputs.

The Panel considered the various mechanisms in place for monitoring, maintaining and encouraging science of high quality and productivity at the level of individual scientists and Project operations. At IRRI, processes and practices that can be considered to contribute to quality include the regular research group meetings, Annual Programme Review, peer review of activities and areas of research commissioned by IRRI or external bodies, staff assessment, participation in competitive grants schemes, *ex ante* analyses of planned activities, making resources available to pilot research activities through the innovation fund, and other studies related to quality. Assessing the quality of science is very complex and needs to be done through meaningful comparison with peer organizations.

6.2.1 Scientists at IRRI

6.2.1.1 Measures of Esteem

The Panel asked IRRI to provide the 'Measures of Esteem' for the period 1998-2003 of internationally recruited staff (IRS), including postdoctoral fellows (PDF) and international research fellows (IRF). The measures included a selected set of indicators reflecting scientific recognition, productivity and linkages, such as publications of different kind, awards, board memberships and invited lectures. These items are ones where external peer review is involved. The Panel also looked at the academic stewardship among IRRI professionals.

In analysing the indicators, the Panel considered only internationally recruited professionals who allocate >10% of their time to research programmes. Productivity in terms of publications varied considerably among professional staff, as can be seen in Figure 6.1, which summarizes the data from those six years. The average rate across the whole of the Institute for the research scientists is two peer reviewed journal papers per year, which would be considered of intermediate to good performance in national quality laboratories in the US, Europe and the like, where there are no other exceptional demands made on research scientists. However, for IRRI, an international Institute that has to deliver many things other than such publications, this production rate is very good. Nevertheless, the Panel **suggests** IRRI should explore what it expects individual professional staff to publish in such journals to sustain career development, to disseminate knowledge and to help advertise the standing of the Centre to attract top quality staff and postdoctoral fellows.

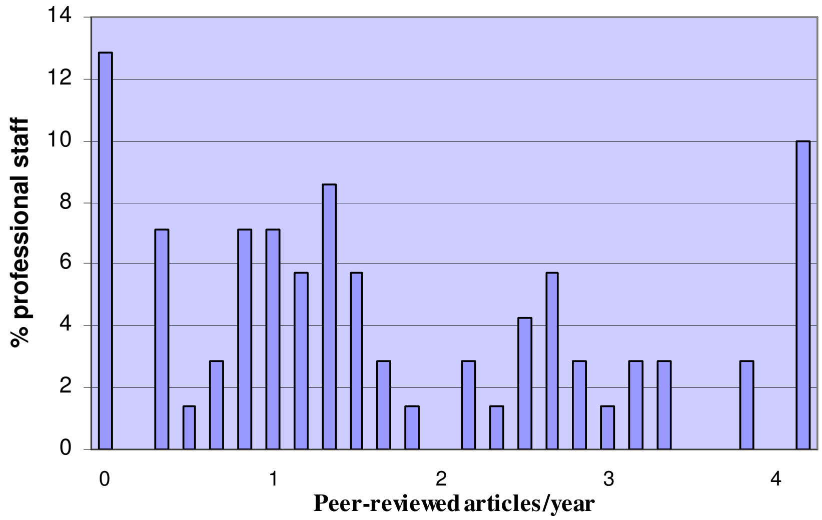
There are 20% of staff members who are not publishing or rarely publishing in international journals. These staff members are mainly post doctoral fellows at the beginning of their career, breeders who focus on the production of new varieties, or outreach staff who focus on applied country projects. Internal peer review via manuscript preparation helps to sustain standards and relevance. Publishing also enhances the value of any accomplishments as it gives others the chance to benefit from it.

IRRI staff have a long standing tradition of publishing high quality books, either internally or in collaboration with scientific publishing houses on specific topics or conferences. These books are professionally edited to a very high standard in-house, and are peer reviewed. They are of particular value as the spread of such books, free to developing countries, has been the major source of up-to-date information as many rice scientists in the NARS cannot access expensive international journals. Over the period reviewed, 82% of professional staff published in different kinds of peer reviewed books at a rate half as high as for journals. This is a good output. The Panel commends the continued output of high quality monographs and books.

IRRI IRS have close linkages to the academic world, which is reflected in the high proportion of staff, some 75%, that supervise students, including MSc, PhD, and postdoctoral fellows. IRRI has a long-standing tradition that its international scientists are invited as guest lecturers and professors at UPLB. Many Asian students also outside the Philippines conduct a PhD study at IRRI and obtain their degree from UPLB, which is well respected. IRRI has contributed significantly to the training of Asian rice scientists through degree programmes. This form of training is especially valuable although often time consuming. Several senior IRS staff members have guest professorships at other Asian, European or American universities.

IRRI IRS also have a high visibility in the relevant scientific world, judging by the number of invitations to deliver lectures and seminars, with 80% of professionals involved. Also, some 40% of IRS have been on the editorial board of peer-reviewed journals, some half of them for more than one journal. Several scientists have received awards and other forms of recognition.

Figure 6.1 – Frequency Distribution of Peer-reviewed Publishing Rate 1998-2003[41]



At IRRI, donor contacts are centrally coordinated but participation in writing proposals for project funding is high. More than half of the IRRI IRS have been main authors in successful grant proposals.

6.2.1.2 Staff Performance and Evaluation

An IRS classification system with weighted impact factors has recently been set up and is being implemented. The system involves a performance appraisal, in which four components are distinguished: (1) impact in product development; (2) impact at the NARS level; (3) impact in science; and (4) impact on organizations.

The weighting factor in each case is determined in a meeting between staff member and supervisor. The main purpose of the assessment is to ensure that the classification decisions are based on an objective, consistent, and transparent appraisal in areas of importance for the Centre. It takes into consideration the unique features of each staff member's duties and contribution. The Panel commends IRRI for implementing this highly sophisticated system.

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[41] Calculated as a proportion for 70 IRS allocating >10% of time to research programmes. Each bar represents a percentage of the staff that published that number of refereed journal papers annually on average in the past 6 years.

6.2.1.3 Retention of High Quality Staff

The recruitment process for international staff is a thorough process. A selection committee is installed by the DG and positions are internationally advertised. Candidates who are selected by the selection committee visit IRRI and discuss scientific and impact issues with teams of scientists during an intensive two-day process. In addition they are asked to give a seminar at IRRI. To date, the quality of candidates is high. IRRI has not had difficulties in filling IRS positions with highly qualified candidates. In 19 out of 20 recent recruitments, IRRI has been able to recruit its first choice candidate. This high success rate reflects the organization's ability to attract good professionals. The Panel confirms, in general, that high quality scientists have been recruited, which reflects the good reputation of science and scientists at IRRI and perceptions of career development.

The quality of IRRI staff is also demonstrated by the fact that many professionals have moved on from IRRI to significant positions in leading science organizations in later life. At the moment, the staff structure in terms of seniority in career and time served at IRRI is well balanced. The Centre must ensure that an optimal balance in each operational unit is maintained to maintain institutional memory and continuity in research.

6.2.2 Mechanisms to Assurance Quality

6.2.2.1 Annual Planning Meeting

The Annual Programme Review meeting gives all research staff the opportunity to review the research Programmes of the Centre. The staff give presentations on projects, strategy and future plans. In the 2003 APM, detailed notes were collated by an external observer to facilitate the discussion and follow-up. At the Centre level, this meeting seems to provide a good and essential forum for exchange of ideas and assessment of general quality of results and plans. What is missing in this planning process is how the results of these sessions are translated by senior management into priorities for the allocation of resources to these projects. Without participation in this key part of the process, staff lack ownership of the results.

6.2.2.2 External Reviews of Projects and Activities

IRRI has commissioned only two CCERs in the review period, with a third currently being conducted but not yet completed. In addition, several projects have been externally reviewed at the initiative of donors or TAC. The Board appears not to have used the CCERs specifically for quality review purposes but rather to guide strategic planning. However, the Panel found that the two CCERs that were conducted were useful and provided credible evidence on quality and productivity, and policy for future development. The Panel **suggests** that IRRI conduct more CCERs in their main areas of work to strengthen monitoring of quality, strategic planning and decision making. Some Programmes at IRRI have been reviewed following external initiative such as the TAC commissioned systemwide review on plant breeding methodologies.

6.2.2.3* Ex ante *Peer Reviews

IRRI does not systematically apply formal *ex ante* peer review processes to Project initiatives. However, social scientists have conducted *ex ante* impact studies on some Projects prior to implementation. In the Challenge Programme process, a large part of the funds is provided through competitive grant procedures where external review processes are applied. In the Water and Food CP, eight of the total of 24, the highest ranking proposals were initiatives led by IRRI, with two of these currently funded. In the other ongoing CPs, such competitive grants systems will be implemented in the following year. This is expected to help to keep the science quality high.

6.2.3 Quality Assurance by Division

At IRRI, Units and Divisions are responsible for quality assurance. The Division Head evaluates the performance of IRS annually. BBU (biometrics) facilitates quality assurance processes with respect to data analysis, collection, interpretation and reporting. There are currently five functional research units, which IRRI is planning to combine into three, and eight institutional service units.

6.2.3.1 Functional Research Units

Refereed journal articles are important as one quality measure, although it is recognized that units such as engineering, genetic resources and breeding have different major outputs. IRRI has analysed its scientific performance over the period 1998-2000 in an internal assessment made of the different types of publications by division[42]. In that study, IRRI produced 346 refereed journal papers, 169 papers in monographs, 15 serials, and 33 books over three years. The scientists publish in high quality journals. Some papers have been published in high impact journals such as *Nature*, *Science*, *Nature, Biotechnology, Plant Physiology*. Through the web of science the citations were determined for several recent publications. The papers were well cited and papers across disciplines were ranked highly. That is a substantial output and the Panel commends IRRI for this demonstration of a good scientific standard.

In its stakeholder survey, the Panel asked for feedback on the value and accessibility of IRRI's research publications. Of a total of 58 respondents, mostly from ARIs and NARIs, who commented on IRRI publications, most found the publications both valuable and accessible. These respondents came equally from all respondent groups. Among most groups there were also those – a minority, who felt that IRRI publications were of varying quality. Seven respondents from NARIs and Southern universities felt that IRRI's publications were not easily available.

The Panel also reviewed the publication list by Division for the entire study period and looked closely at the ten most significant publications of each functional unit, as determined by the units themselves.

Plant Breeding, Genetics and Biochemistry (PBGB): The PBGB Division focused more on biotechnology and the breeding process in recent years instead of biochemistry. The department has 11 breeders and 4 biotechnologists among the IRS staff. Several IRFs and PDFs are active in this division. The Division staff is highly qualified. The main output of the breeders being varieties, they publish less. On average the breeders published 1.4 refereed

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[42] Ramos, M.M. and C.S. Austria: Knowledge Sharing in Rice Research: the Literature Output of International Rice Research Institute Scientists, 1990-2000.

papers per year. However, the molecular biologists publish much more (average 4.3 refereed papers per year) than the average standard in advanced institutions for their discipline.

The Division strongly supports the research Programmes. In the favourable systems the breeders have been very active in the NPT process (developing resistant NPTs). In the unfavourable environments the breeders had successes in the uplands, rainfed lowlands and in developing aerobic rice varieties (spin off of the upland programme). (See Chapters 3 and 4).

The reduction in overall budget has led to a reduction of the breeding programme. In Ubon, Thailand the RLR breeding programme was stopped and at IRRI headquarters the size of the breeding programmes has diminished.

Crop Soil and Water Sciences Division (CSWD): The Divisions on Agronomy, Physiology and Agroecology and on Soils and Water Sciences have been merged in the review period. The Division has 14 IRS positions and several IRF and PDF positions. The scientists work in Programmes 2 and 3 and strongly contribute to the NRM projects. The Division is well equipped. The Division has a long history of high quality science and publications in high impact journals. On average, CSWS scientists published 2.6 refereed papers per IRS per year, which is high. In this Division, a high turnover of staff has taken place but high quality new staff have been found to fill some of these positions. CSWD has faced an overall decline in IRS from 24 to 14 in the past three years.

Entomology and Plant Pathology Division (EPPD): The Division has 8 IRS positions and several IRF and PDF. On average, they published 2.5 refereed journal articles per year. The international standing of the Division is high. In the Division, IPM methodologies have been developed involving farmer participatory approaches.

Social Sciences Division (SSD): In this Division 5 core IRS, 2 IRFs and 2 PDFs are currently employed. They published 1.7 refereed journal papers per scientist per year and a large output in books, conference papers, etc. They contribute to Programme 3 and Programme 4. In the Panel's judgement, the increased need for social scientist input in Programmes 2 and 3 indicates the need for strengthening the Division.

Agricultural Engineering Unit (AEU): This Unit has been reduced in size and the IRS now also run the IRRI farm and conduct the post harvest work that is expanding because of the ADB funded programme.

6.2.3.2 Institutional Services

Communication and Publication Services: The Panel commends IRRI for changing from the Annual Report and Technical Programme report to the Rice Today magazine, and for the DG report for details on Project progress and publications in journals and proceedings. Much has been put on the web and IRRI is commended for this. IRRI books have been extremely well used and cited by (rice) scientists worldwide. The policy of distributing books to all relevant libraries in developing countries has been very instrumental for the spread of scientific achievements through the scientific community in rice growing countries. Most libraries have no resources to purchase expensive journals or books. With the increasing importance of the Internet also in developing countries it is very important that IRRI continues with web-based publications, but it is recognized that this is not a straightforward process. The IRS in the team received several awards for design of covers, photography and articles in the press.

Genetic Resources Centre: This is the world's main storage of rice germplasm although for safety reasons most of the germplasm is in a duplicate store at the USDA-ARS National Centre for Genetic Resources Preservation, Fort Collins (USA).

In 2003, the NRS of GRC received the CGIAR 2003 Science Award for best support team based on the upgrading of procedures, technologies and infrastructure of the International Rice Genebank Collection. See Chapter 2 for more detailed discussion on the Genetic Resources Centre.

Central Research Farm*:* The Panel visited the farm, and especially the new post harvest systems for operation and demonstration purposes were shown to the Panel. This is an important development especially in view of the enormous losses of rice in the post harvest process of up to 20%. The farm is run well and a database has been developed to keep records of field results.

Other Units: These units include: Climate Unit; Seed Health Unit; Analytical Service Laboratory; Biometrics and Bioinformatics Unit (Chapter 2); Information Technology Services. These units were thoroughly reviewed during the 5th EPMR and the Panel learned that these service units still keep up the high level of service. Some services were visited by the consultant and he confirmed this view.

6.3 Partnerships for Relevance

As a mission-oriented organization IRRI constantly checks the relevance of its work against the context of the world in which it operates. As noted in Chapter 1, this world is changing fast. The pace of science and technology has accelerated, and the growth and complexity of the economies of the rice producing countries in Asia have increased in the past five years. The demands on IRRI could easily lead to it becoming all things to all people and losing focus. These changes also challenge IRRI's identity and function, with the need for regular review and recurrent articulation. IRRI is helped in this process through its close operating partnerships with a wide range of organizations, both among rice producing countries and more broadly. These relationships are crucial to the successful and effective delivery of its mission, helping to guide the planning process and are essential to the effective delivery of research results to alleviate poverty.

IRRI does not work alone. Historically the Institute has developed strong working relationships with the agricultural agencies of rice-growing countries and has a tradition of collaborative science with many leading ARIs built on mutual scientific respect. It has an array of interactions with these, where rice is the connecting theme, and information, products, and services flow between and among the partners interactively. Previous chapters have concentrated on what is being exchanged, but this section tries to capture the why, who and where of these interactions.

6.3.1 National Agricultural Research Systems, Non-Governmental Organizations and the Private Sector

IRRI has bilateral arrangements with sixteen rice-growing countries in Asia, with offices in ten of these to support research and training staff located in those countries. Each of the sixteen countries also has a delegated IRS staff member at IRRI acting as resource and liaison person; this has been a very successful arrangement in providing a single point of scientific contact within headquarters for each country. IRRI does not maintain the same links with countries in Africa or the Americas, but it does have an important role of long-distance provider of germplasm, advanced degree training, limited support to NARS undergraduate and technical training courses, and sponsored consultancies.

High levels of activity are maintained in countries such as Japan, Korea and China, with greater levels of economic development in topics such as plant breeding, genetics genomics and NRM (in the case of China), as well as in some countries that are at a low level of economic development or national capacity such as Laos and Myanmar. Lower levels of activity may result from completion of externally funded special projects or changing political circumstances, but low income countries[43] and poverty affected regions of large countries will always be IRRI's primary target of concern. Funding and cessation of special bilateral projects between individual countries with IRRI and donors changes the balance of these interactions with NARS from time to time, and inevitably lead to a degree of *ad hoccery* that does not make it easy for the Centre to plan and deliver its Programmes in a strategic manner.

In discussion with country representatives, Panel members were told that once GDP per capita reaches a certain level (IRRI work suggests $1500/pc/yr) the proportion of rice (or other staples) in the diet falls significantly, and therefore for countries such as Thailand and Korea, the need for a country office was questioned, other than for those types of interactions that would be entered into with developed countries in advanced research areas. For the mid-range countries, where GDP per capita is between US$500 and US$1500, there are generally significant regional or localized problem areas that would benefit from IRRI's work, but IRRI's involvement appears patchy or sporadic. For the poorest countries there appears to be a genuine need for continuing the long sustained involvement by IRRI in capacity building for rice research and production.

Despite recent down-sizing at IRRI because of restrictions to funding, there is still much the same level of expectation among most countries in the region as five years ago. Responses to the Panel's questionnaire and interviews with NARS partner organizations indicate that in some areas, such as 'upstream' areas of research (bioinformatics, genomics, and other areas of advanced rice germplasm improvement), the demand for research collaboration and specific training has increased in recent years. This poses interesting questions for IRRI on which areas of training and knowledge interchange run at current, increased or decreased levels in the future. The Consortia provide a useful mechanism for addressing this question. Through the Consortium approach, steering committees of partners can identify priorities for training and information exchange, as well as research (Chapters 3, 4 and 5).

The basis for IRRI's attractiveness for both NARS and ARIs is its impartial international nature, with freely available public goods and a long established reputation for

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[43] Using World Bank economic classification: low income economies <$US 760/capita/year.

scientific excellence, which commands respect from peers in leading research institutions around the world.

Compared with five years ago, the Panel considers that IRRI-NARS interactions have strengthened considerably through the expanded role of the two major Consortia (IRRC and CURE). The Consortia have evolved into much more meaningful partnerships where research is trialed at on-farm sites as well as long-term station experiments, regional priorities are considered and acted upon together, feeding upwards into the management decisions of individual countries and IRRI, and where participatory research, training and information dissemination are all shared as a collective responsibility. The Panel considers that the role of these two Consortia can be expanded even further in the future (see Chapters 7 and 8). However, not all countries with which IRRI maintains close relationships are covered through these Consortia, and not all objectives and activities are most appropriately targeted through their structures. Many of the specific biotechnology and pre-breeding interchange activities are supported by separate Networks of interested parties for example (Chapter 2). In addition, IRRI maintains a considerable level of interaction all round the world with countries, institutions and individuals on different aspects of rice.

In Asia the strength of the NARS is considerable, and IRRI has not historically had to rely heavily on relationships with non-governmental organizations (NGOs) for assistance in germplasm distribution, information dissemination or participatory research, as has been more common for example among the IARCs in Africa. However, there are many specific instances where IRRI works closely with particular NGOs to achieve widespread dissemination of particular technology interventions. For example, NGOs are assisting with delivering IPM packages widely in Bangladesh (Proshika), Thailand (Population Community Development) and through other parts of the region (World Vision). The Seed Health Improvement project in Bangladesh has partnerships with a large number of NGOs including CARE, Proshika, Grammen Krishi Boundation and BRAC.

The 5th EPMR made a point in favour of increased partnerships with the private sector. The potential value that links can bring IRRI is often substantial and clear. However, where these benefits come at a price for the institution's status or for its clients, then the links can be very questionable. IRRI has developed a policy[44] which this EPMR supports. IRRI now has a much more mature position than five years ago, created in part by its experience with the Golden Rice project. The argument for interaction with other parts of the private sector, such as in manufacturing of engineering equipment (harvesters, threshers, rice mills) is similar. While IRRI has been an active researcher and developer of innovative rice industry machinery, its role is to demonstrate the advantages that such prototypes represent in terms of market opportunity to the private sector and stimulate commercial development that will assist the adoption of more sustainable, productive and labour saving rice production. This is the principle that underlies the new initiatives in post-harvesting research and development in Programme 2, and has already been successful in stimulating local manufacture of direct seeding and harvesting equipment in the rice-wheat sector in Pakistan and India. The Panel commends IRRI for maintaining a judicious and balanced relationship with the private sector, in keeping with its role as an international distributor of public goods.

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[44] IRRI's Policy on Partnership with the Private Sector.

6.3.2 Linkages with ARIs

IRRI already has a wide range of relationships with a number of selected ARIs in shuttle breeding programmes, genetic material and data sharing activities. For example, it maintains a range of data base services that are freely accessible through its web site, such as IRIS, the International Rice Information System that provides up-to-date global information on genetic resources, including germplasm pedigrees, field evaluations, genomics, genetic and environmental maps. A number of ARIs collaborate in providing this information, strengthening its overall scope and completeness. Similarly, IRRI maintains and regularly updates free databases on world rice statistics that are, in the Panel's opinion, more reliable and current than others. All rice producing countries find these services valuable.

In the past five years the number of ARIs, both in the public and private sector, working on rice worldwide has expanded substantially as described earlier in this Report. This increases the opportunities for IRRI to draw on a larger pool of outstanding scientists who are at the forefront of in rice biotechnology, modelling, production environment characterization and so forth, beyond its existing linkages. As mentioned in Chapters 2 and 8, IRRI relies very significantly on certain ARIs for rice genomics and maintaining these links is vital to its goal of characterizing and developing better germplasm. Responses to the EPMR Questionnaire indicated that a number of leading research institutes would be interested in locating scientists at IRRI on guest fellowships, and in attracting national research foundation support for post-graduate students for joint research projects. The opportunity certainly now exists to interest a wider range of research institutes in focussing their attention on rice and rice growing areas in joint research proposals.

The Panel **suggests** that IRRI stimulate joint research proposals from alternative national research funds from leading institutions to conduct research on cutting-edge topics, which would draw a larger critical mass of visiting scientists and post graduate students to rice research located in IRRI's headquarters at Los Baños.

6.3.3 Consortia, Networks and Bilateral Development Projects

6.3.3.1 Consortia and Networks

IRRI has initiated or is part of a considerable number of networks and consortia, set up to assist cooperation between countries and organizations in specific areas of rice research and development. Most of these have been commented on in previous chapters, with discussion particularly on the role of Consortia now and in the future. The following list assists the reader to locate these discussions:

1. IRRC: the International Irrigated Rice Consortium is currently Project 6 and is extensively discussed in Chapter 3 and Chapter 7.
2. RWC: the Rice Wheat Consortium, a system-wide consortium which is led by CIMMYT, with IRRI as an international partner, operating in the Indo-Gangetic Plain, and part of Project 4 of Programme 2 (Chapter 3).
3. CURE: the Consortium for Unfavourable Rice Environments, currently Project 9 in Programme 3 and extensively discussed in Chapter 4 and Chapter 7.
4. IRFGC: the International Rice Functional Genomics Consortium (Chapter 2).

5. INGER: the International Network on Genetic Exchange in Rice, an informal partnership among the NARS of the world's main rice growing countries and the three IARCs with mandate for rice, that is IRRI, WARDA and CIAT (Chapter 2).
6. CORRA: the Council for Partnership on Rice Research in Asia (Chapter 2).
7. ARBN: the Asian Rice Biotechnology Network (Chapter 2).
8. Golden Rice Network: consisting of five active partners in three countries (India, Philippines and Vietnam) but in the process of revision and dialogue for future strategies for vitamin A in nutrition-related malnourishment.
9. IPSWAR: the International Platform for Saving Water in Rice (Chapter 3).

This impressive list demonstrates IRRI's overall level of engagement with NARS in Asia and with a number of the advanced institutes in the region and more widely in the world that are actively involved in rice improvement, production systems and delivery of research results to local communities. Networks do not normally seek to implement field based research and development among multiple partners in the same way as the Consortia described in Chapters 3 and 4, but rather act as information and germplasm exchange mechanisms, often on relatively small budgets beyond that supplied by the members themselves to meeting activities. Some are at the mercy of fluctuations in external funding such as INGER, where there has been a decline in a previously strong and active network attributable to withdrawal of these special project funds. In these circumstances, networks still function, but in much the same way as scientific professional societies, by convening workshops and other information exchange mechanisms and are valuable for these functions but cannot undertake much more.

In the case of INGER, other mechanisms for funding need to be sought for what has been a high-profile, valuable activity. It would seem that one alternative mechanism, which does not put the whole onus on IRRI's tightly stretched funds, would be to consider some type of membership contribution, particularly from the better off countries in the Network.

The Panel recommends that IRRI establish a forum of rice growing countries with the purpose of financing and revitalizing INGER.

Although PETRRA (Poverty Elimination Through Rice Research Assistance) is listed as a network, it is discussed among the bilateral special projects because of its scale and functions.

6.3.3.2 Bilateral Development Projects

IRRI has had a long tradition in being a partner in bilateral projects between individual countries and donors. For example, IRRI has assisted the Government of Myanmar through formal bilateral arrangements since 1977 until 2002. In the 25 years of this collaboration, five major bilateral country projects, funded in large part by CIDA and IDRC, and numerous smaller projects have been carried out to help increase rice production to one of self-sufficiency, contributing one third of the gross domestic product of the country. The final impact study carried out by IRRI in 2002 found that for a total investment of $US2.2M there had resulted in a net present gain of US$140 M, equivalent to a rate of return of 155% per year for the past 25 years[45]. Project work has also been conducted to strengthen the country's

[45] Shrestha, S. et al. 2002: An economic impact assessment of Myanmar-IRRI country programs. IRRI Los Baños, Philippines.

agricultural research capacity, improve nutrient management, and in particular find sustainable low cost organic based nutrient systems after the withdrawal of fertilizer subsidies in the 1990s.

Large impact bilateral projects have been carried out in other poor Asian countries, particularly Bhutan, Cambodia and Laos. In all these countries agriculture occupies over three quarters of the population, and rice constitutes the major basic food. Bilateral programmes, with IDRC, SDC and Ausaid long-term donor support, have been the principal mechanism by which the governments have been able to develop national agricultural research organizations, with a cadre of trained personnel, infrastructure, and a national rice germplasm collection, including the recovery and utilization of many hundred landraces and wild rices.

Two major projects were active at the time of the review and Panel members visited both. A 15-year capacity building project in the Lao PDR will finish in 2005, by which time the national research programme is expected to be in a position to run independently its national rice breeding and selection, rice agronomic research with applications in upland and lowland environments. The project has included infrastructure development, collection of the national rice germplasm (over 13,000 accessions), development of improved varieties from indigenous material, and evaluation of systems of intensification and diversification appropriate to local specific environments. The present phase is on capacity building with in-house training of national staff in all aspects of research from basic English and field technical support to advanced post graduate studies. Ninety percent of rice research funding in Laos comes from this project, and there is substantial uncertainty as to where alternative funding may be coming from to support key activities such as germplasm collection maintenance and in-house training once the present project ends. Comments were made to the Panel that although a better exit strategy is being developed than occurred for the similar project in Cambodia that finished in 2002, there is still the danger that a large gap in continuity could see much of the present impact diminished, as has happened in Cambodia.

PETRRA, an even larger project managed by IRRI in Bangladesh and supported by DFID, is in its final phase and will not run beyond 2004. This ambitious project is targeting the need for improved overall management systems of current intensive rice production in districts that have high population densities and growth rates above 2.5%. There is a large emphasis on participatory approaches with more than 45 NGOs and non technical facilitators working with BRRI and IRRI scientists, and engaging with over 500 villages in eight regions. The project is also working on a number of policy issues, and on women-led extension capacity building. As with many technology transfer projects it inevitably draws upon the achievements of the past from a number of sources, such as the Urea SuperGranule (USG) and the input sector distributor network, that was set up through a long period of earlier work undertaken by the International Soil Fertility and Crop Development Centre (IFDC). The project is coupling this approach with accelerating the introduction of IRRI-BRRI improved varieties and SSNM and IPM ‘packages’ in systems of sustainable production. The size and range of objectives of the project are impressive.

There are some common characteristics of such projects. First of all, they are largely in the downstream area of applied research which may rightly be called development. Their intention is to see the adoption of better practices and crops at a faster rate over wide areas as the best means of tackling poverty reduction. As such, they are clearly central to IRRI’s main objective. They are distinguished by having very clear time lines and objectives, which are closely monitored by the donor through external reviews. As a result of normally having *ex* *ante* and *ex post* impact studies built into the project evaluation, the donor is able to obtain a good estimate of the relative success of the project. These are all excellent features. However, a few concerns remain in the minds of the Panel. These are the exit strategies (particularly for very poor countries) where the supposition that internal country resources will be sufficient to maintain salary and operating costs of research and extension personnel after the project finishes may be unfounded, and the tendency for them to operate very largely as completely independent units from the rest of IRRI. In addressing the issue of exit strategies, the planning process should view these independently from the project funding, and possibly engage an independent consultant such as FAO to develop an on-going management strategy that can maintain the impetus and value of the good work done within the project.

6.3.3.3 The Overall Role of Partnerships

Without this very large set of partnership arrangements, IRRI would cease to function in its present capacity. The range of partnership activities is very wide, and provides an adequate mechanism so that IRRI can draw adequately on the world knowledge of rice science, listen and respond appropriately to clients and deliver targeted research results to where they are most needed.

There are alternative models that could provide the same function: for example, by having a larger network of country offices with more IRS in outreach locations. This has been the model used in several other large CGIAR Centres that have mandates that cover crops grown in widely distributed parts of the globe. Would the future security of rice production for the poor be better served if IRRI were to adopt this model in the future, especially if there is strong demand to shift its distribution of resources further into new areas of need? It could be argued that current arrangements do not give IRRI sufficient visibility and presence in some Asian countries (such as those which are still in the low to medium wealth categories and have no country office). On the other hand, the effectiveness and speed that IRRI can bring to bear in solving a research problem has certainly been greater from having a critical mass of specialists located in one spot where they have access to the range of support services, especially in laboratory facilities, IT and biometrics. These are to some extent issues of equity versus efficiency. This is not for the Panel to debate, but should be on IRRI's list of issues to investigate further.

The Panel recommends that IRRI commission a study, based on the vision of IRRI's role in 5-15 years, to assess the relative merits of the current model comprising some outreach activities but with the majority of scientists in headquarters, with a model which has more outreach research staff in all those rice producing countries where close proximity and visible presence are deemed necessary.

The Panel cannot over-emphasize the importance of having effective Partner relationships in fulfilling IRRI's effectiveness. Management and IRRI scientists fully appreciate this, but there is always some tension in working to accommodate a wide range of country and donor priorities. The Panel noted that these tensions inevitably lead to some degree of short-term *ad hoc* solutions in terms of the distribution of resources and research effort across countries. Elevating the role of Consortia both within IRRI and externally to have a more visible presence should reassure donors to the relevance of IRRI's work.

CHAPTER 7 – GOVERNANCE, LEADERSHIP, MANAGEMENT AND CONTROL

7.1 Introduction

In its 44 years, IRRI has achieved an enviable record of successes in its scientific endeavours, and millions of the world's population have benefited. Today, its reputation in the worldwide scientific and donor communities and in 'the public eye' is excellent, and its managerial and financial competencies and integrity are well regarded by all who review the Institute's activities, including this Panel.

For reasons totally unrelated to the CGIAR System, (high profile financial scandals in multi-national organizations; the subsequent failure of a major auditing firm, and the resultant increased legislative focus on governance) the management and boards of all organizations – for-profit and not-for-profit alike – are coming under increased scrutiny. The CGIAR System is not immune from this shift in oversight and, as IRRI moves ahead, it too will face increased scrutiny of its managerial and governance activities. Indeed, with the request of a Donor for a Board statement on risk, this trend has already started.

Many of the challenges ahead will fall directly on IRRI's Board of Trustees and in addition to reviewing the Centre's overall operation from a management perspective, the Panel has also looked at how IRRI can best position itself with its clients, its donors, and in 'the public's eye' to meet these oversight challenges.

7.2 The Board of Trustees

IRRI's Board of Trustees is composed of 15 members: 12 of whom are members-at-large and 3 are *ex officio*. The Secretary of Agriculture of the Republic of the Philippines, the President of the University of the Philippines and the Director General of the Institute are appointed *ex officio*, and of the 12 at-large members, 3 are CGIAR designated members.

The Board meets formally twice a year and its four Standing Committees (Executive, Finance and Audit, Program, and Nominating) meet at least as often, and as needed. As explained in the Board of Trustees Handbook, all Officers, including the Director General (DG), are elected by majority vote of all the Trustees. The Handbook also states that the Board sets the policies; and that the DG reports to the Board, works under the Board's direction and is responsible for carrying out the Board's policies.

The Handbook also prescribes the Board's own performance assessment process that is based on a Self-Evaluation questionnaire. A new Chairman of the Board has been elected and took office as of January 1st, 2004.

7.2.1 Overall Assessment

Members of the Team attended a meeting of the full Board, and all Committee meetings, and then met individually with each Trustee attending the Board meeting in Bangladesh.

Like other CGIAR Centre Boards, IRRI's is in transition from the 1960s' governance model to a current model that is being driven, in part, by the world wide public demand for improved governance and by such imposed initiatives as the USA's Sarbanes-Oxley legislation. In this context, the Team notes a current request by one donor (DFID) for formal Statements by the Board of Trustees about IRRI's (a) risk assessment and (b) the adequacy of the internal controls, including the degree of compliance with CGIAR principles and guidelines. This donor initiative is, no doubt, just the first of many donor-led initiatives aimed at demanding better governance in the CGIAR System.

The differences between the old and new governance models are striking. The changing demands being made on Trustees of CGIAR Centres are summarized in Box 7.1. The IRRI Board is to be commended for its prompt and appropriate efforts to respond to the DFID request: it has created a Task Force of Trustees to work with Management in developing the formal Board response by April, 2004. Some of the IRRI Trustees are acutely aware that, in complying with the DFID request, the Board's formal response will, for the first time, explicitly place the liability for any future problems squarely with each Trustee, both current Board members and also all future Board appointees. A brief overview of what is typically required of a Board of Trustees by Donors in this instance is provided in the Box entitled 'Board Reporting on Risk Management…What is Required' on the following pages.

The Board has the ultimate responsibility for everything IRRI does. In assessing the work of IRRI's Board, the Panel looked at those key governance tasks that a Board undertakes: developing strategy; monitoring the Centre's activities; recruiting and orienting board members; and monitoring its own performance.

7.2.1.1 Developing and Monitoring Strategy

A number of Trustees stated that they did not have a significant input into the strategy development process at IRRI – neither in the Program Committee nor in the full Board meeting. Some felt it unnecessary to sit through lengthy scientific presentations by staff (that may have been wholly appropriate under the 'old' governance model) when what they should be doing is focusing their scarce time and efforts towards guiding the future of the institution – working closely with Management in developing the Strategic Plan and monitoring its implementation.

By way of example, a few Trustees feel that Management's current efforts to update the 1996 Strategic Plan may not be the best approach given the shifts in funding, the changing IPR landscape, the increased funding and quality/relevance of private industry research, and other factors that are/will impinge on IRRI's future in rice research. Updating an existing Plan, they said, is less likely to encourage valuable *ab initio* thinking. In this context, the Panel encourages management to limit scientific presentations in future board meetings – presenting the main material either in written form at other times during the year via email, or in the context of the Program Committee meetings. The Board Chair, in close consultation with the DG, would then have sufficient 'meeting time' to implement an agenda that focuses the Board's limited time and considerable skills on the Centre's strategic direction, on the plans and budgets for getting there, and on measuring Management's performance in achieving the Board's directives.

This change, however, places a much greater burden on each Trustee to (a) have read the material sent by Management; (b) fully understand the nature of the governance functions expected of him/her; and (c) be prepared to debate and inform the strategic issues at hand. Some Trustees may find this change in role difficult without some training.

7.2.1.2 Recruiting Board Members

As IRRI's future strategy is developed and implemented, it will be critically important for the Board's Nominating Committee (NC) to identify potential candidates whose competencies closely match the Centre's emerging needs. At the most recent NC meeting to consider candidates for 2004-5 Board vacancies, it was not clear that the Committee's list of potential candidates adequately reflected the Board's perceived competency requirements[46] that specifically requested CVs of candidates with IPR/legal, or finance/treasury competencies. Nor were there candidates representing the for-profit segment, even though it is clear that closer interactions with that sector are being pursued by IRRI.

Absent the new strategic plan, the Panel does not presume to know what set of competencies will be required: it is concerned, however, that the nominating process be one that identifies the most appropriate candidates to effect good governance. As an example of the effects of changing governance expectations, under existing laws[47] IRRI does not have a quorum of 'qualified' Trustees on its Finance and Audit Committee.

The Panel recommends that, annually, the Nominating Committee develop a List of Trustee Competencies required by IRRI over the next 5 years and, on approval by the Board, develop its list of potential candidates accordingly. This List should also be a key input in the Board's decision as to whether a second term should be offered to current Trustees up for re-election. Automatic second term election, even where there are no adverse circumstances suggesting otherwise, should not be the norm.

This is particularly important in IRRI's case where a relatively high percentage of Trustees are either *ex officio*, or are nominated representatives of certain country, or donor constituencies. While the Panel does not believe this 'reserved seat' concept is in IRRI's best overall interests, at least the List can also be a useful guide for the Constituency officials as they seek to identify and nominate their representatives to the IRRI Board.

7.2.1.3 Orienting Board Members

The Panel commends IRRI for arranging for the incoming Board Chair to attend the Harvard Business School's 'Governing for Nonprofit Excellence' course as part of its ongoing efforts to bring the Centre's governance activities more in line with best practices. What the Harvard and similar programmes uniquely provide is a course designed specifically to examine best governance practices worldwide and to enable participants to interact with, and learn from, a large number of Board Chairs from a widely different set of non-profit

[46] Minutes of IRRI BoT meeting, April 2002.

[47] While the US Sarbanes-Oxley legislation is not directly applicable to IRRI, such legislation is quickly becoming the *de facto* standard by which Donors (e.g. DFID) will measure Centre governance performance. Under Sarbanes-Oxley, a Trustee must be "qualified" to be a member of the F&A Committee of the Board. *Inter alia*, **all** members must be independent of management; **all** must be able to read and correctly interpret financial statements; and **at least one** must be a 'financial expert' as defined by Sections 301 & 407 of the Act.

organizations. This wide exposure to best practices by governance practitioners is an essential component of the learning process. The CGIAR Secretariat has advised that it is also reviewing governance training.

7.2.1.4 Keeping the Board Informed

As IRRI's Board moves towards the new governance model, Trustees will demand much more information from Management concerning the Centre's operations. Increased Trustee oversight responsibilities and the concomitant liability exposure will require that they be well informed, on a regular basis, about the Centre's operations. The Board, at present, receives three financial reports during the year on the Centre's operations; the Treasurer's report as of April and September[48] and a new quarterly report on finances. As has now been evidenced at some other CGIAR Centres, this paucity of information leaves Trustees vulnerable to accusations of poor governance.

The Panel recommends that IRRI provide all members of the Finance and Audit Committee with:

- **(i) a monthly Cash Flow forecast for the ensuing 6 months;**
- **(ii) monthly income and expenditure statements (with actual vs. budget comparisons and commentary);**
- **(iii) quarterly reports on Project costs and revenues – highlighting those where cost under/over runs exceed 10% and articulating what management is doing to resolve the issues; and**
- **(iv) monthly reports on investment income compared to budgeted income.**

All Board members should receive this same information on a quarterly basis, and all these reports should be available to Board members within 20 days of the end of the reporting period.

7.2.1.5 Monitoring the Board's Own Performance

The Board's own self-assessment process has worked sporadically in the past, but is now in regular use. The Board is considering changes in the format for the future, but based on the results of the last self-assessment of the most recent Board meeting (Sept 03), Trustees generally viewed themselves as being 'strong' in attendance at Board meetings, in devoting sufficient time to Board activities, participating in the discussions, and in their overall commitment to IRRI. Conversely, their ability to offer innovative programme ideas and other ideas leading to scientific excellence; their participation in IRRI activities outside of the two formal meetings each year; and fund raising activities, scored less well. What is needed now is that this important feedback from such self-assessments be collated by the Board Chair and turned into useful recommendations for improvements for the Board's governance activities as a whole, and used as the basis for individual counselling sessions between the Board Chair and each Trustee on a regular basis.

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[48] Individual Trustees do get some additional information pertaining to their specific area of responsibility in between board meetings on an as-needed basis.

The ultimate test for the Board, however, lies in the extent to which it will guide the strategic direction of the institution, and keep Management's focus on the path ahead. In this the Board apparently feels that substantially increased involvement by them is appropriate and the incoming Board Chair will need to address this issue quickly – particularly as the new strategic plan is being developed.

Box 7.1 - The Changing Demands on CGIAR Centre Trustees

The governance function is changing dramatically today as a result of recent scandals in all areas of business activity – in the for-profit, and non-profit sectors alike. The concomitant demands on Trustees of CGIAR Centres are changing and are much more challenging than heretofore.

Faced with these new realities, the role of a CGIAR Centre Board is no longer primarily one of establishing and guiding the scientific mandate, but now includes:

(a) providing strategy-driven direction in an increasingly fluid, funding-driven environment;
(b) ensuring that the Centre is being managed efficiently and effectively;
(c) ensuring that the Centre's project palette and the core competencies of its staff remains aligned with the Centre's vision, and with its 'marketing' and fundraising activities;
(d) providing leadership in identifying and accessing new funding sources – particularly the private, for-profit and private-philanthropic sectors where no one donor has the virtual 'right' to Board representation; and
(e) lending credence to donors as to the excellence of the governance function.

The core competencies of the Board will also have to be expanded from scientific expertise to also include:

(g) enhanced financial and administrative experience to provide the intellectual leadership in current governance topics such as risk management, human resource management, financial, treasury, and accounting controls, and performance measurement metrics;
(h) working knowledge of, and experience with, project management tools and techniques; and
(i) familiarity with, and access to the private sector;

Further, (and CGIAR Centres' usual diplomatic immunity clauses notwithstanding) it is not at all clear that Centre Trustees – particularly those from Part 1 countries – are immune from liability suits brought against the Board for inadequate governance. Boards therefore must be much more aware of, and suitably insured against, liability judgements.

7.3 Leadership and Culture

The Director General establishes the tone and culture that imbues an organization. With a total staff complement of some 889, representing no less than 24 nationalities, it is clear that leadership plays a critical role in the human resource function at IRRI. The large size also sets a challenge for disseminating the culture throughout the organization.

The 5th EPMR recommended that IRRI embark on a period of stabilization to enable the newly appointed DG to assume control after a previous period of management turmoil and to allow time to customize and improve the matrix management processes. The Senior Management team is to be commended for its achievements on these points and its ability to maintain an active, participative staff during a difficult period of downsizing where the total staffing complement has been reduced from 1,115 to 889 over the past 5 years.

Productivity and standards of operation have been high. The positive outcome of this review is testimony to the daily culture being good and clearly the IRS and NRS staff are well motivated. One event was unfortunate: an entire group of Staff Association representatives resigned from the Association as a symbolic protest against Management's perceived lack of interest in resolving issues.

In a research based organization like IRRI, a culture that inspires creativity is essential. With so many research opportunities and a specific mission but limited funding, priority setting and the concomitant rejection of many good ideas is also essential. Priority setting, to be useful and accurate, must derive from top-down, and from bottom-up scenarios. This will happen when there is a climate that encourages open debate among and between senior management, creative scientists, Project Leaders, and indeed staff at all levels such that scenarios are evaluated, ranked and chosen according to agreed criteria. Only then will staff 'own' the outcome of the debate. The Panel senses that these debates are not as frequent or as healthy as staff would like, in spite of all the formal time devoted to planning. 'Ownership' is reinforced as staff fully understand what decisions are made – particularly the prioritization decisions – and how these decisions are made.

IRRI has led the world in rice research in the past: it is now faced with much greater and growing competition in a number of areas and must sustain a relevant comparative advantage to assure its future. The debate that will inform, guide, and ensure this will be detailed, difficult, and have far reaching consequences in terms of funding sources, staffing competencies and investment requirements. The DG, together with the Board, will always need to establish and encourage a forum that is conducive to scientific enquiry and learned debate where, at the end of the process, staff have personal 'ownership' of the agreed vision and strategy. Creating such an environment is always a challenge for the DG, and the Board is urged to recognize this as a leading indicator of performance as it reviews the DG's performance at the next formal review.

7.4 Organizational Structure and Programme/Project Management

The Current organization structure at IRRI is as shown in Figure 7.1.

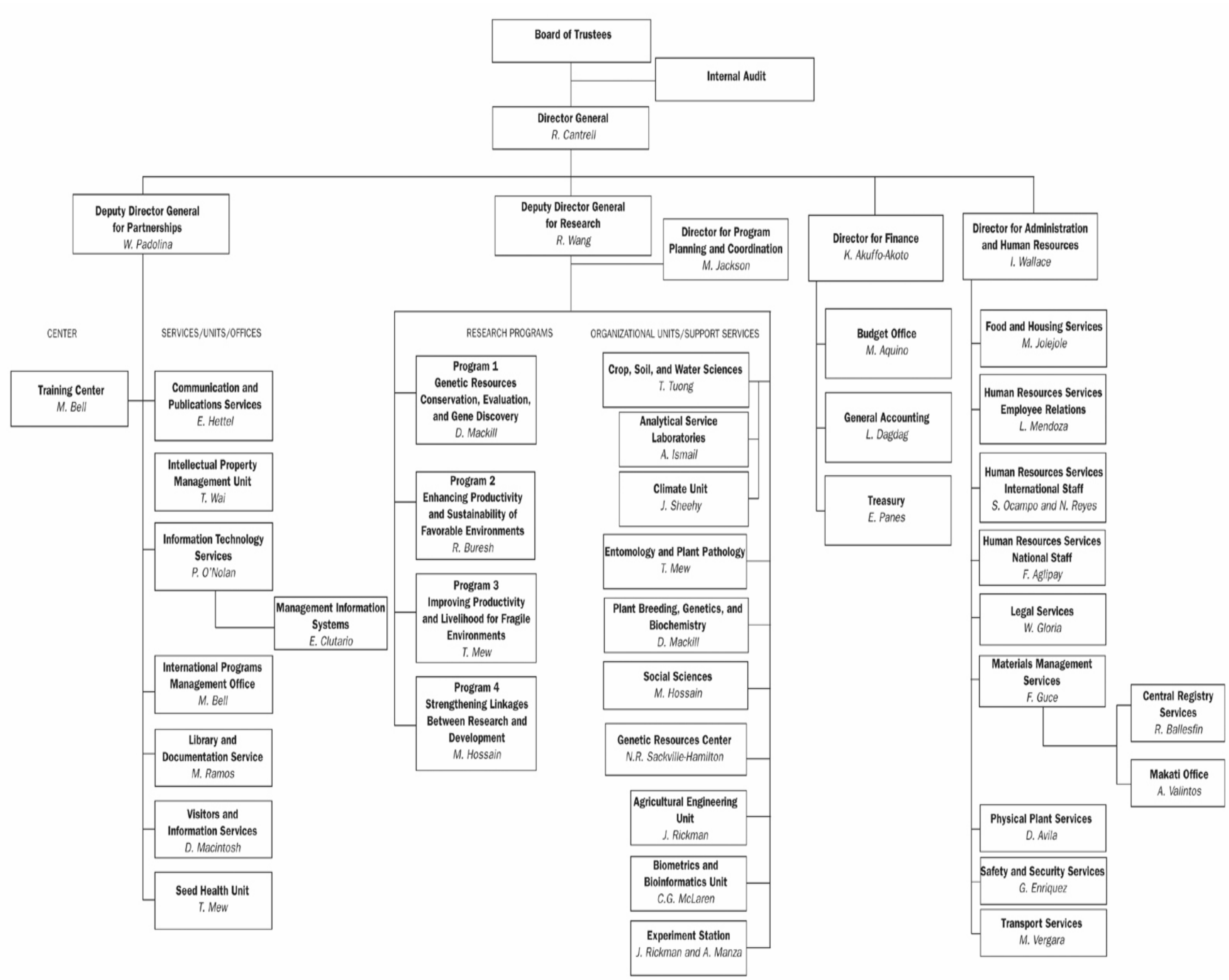
In response to one of the recommendations of the 5th EPMR, IRRI changed the management structure from an ecosystem based structure to one where four programmatic themes became the structural fabric into which existing Projects were mapped appropriately.

The four programmatic themes are:

1. Genetic resources, conservation, evaluation, and gene discovery;
2. Enhancing productivity and sustainability of favourable environments;
3. Improving productivity and livelihood for fragile environments; and
4. Strengthening linkages between research and development.

Project Management is effected through a multi-dimensional matrix management (MM) approach that devolves the budgetary and output management responsibility for each Project to the 12 individual Project Leaders. Project Leaders manage a single Project and report to one or more Programme leaders and also to the Division Heads of their primary scientific discipline. The strategy formulation and planning of the overall project palette lies with the four Programme Leaders who themselves report to the DDG-R.

Figure 7.1 – IRRI Organizational Structure



Further enhancing the matrix are four Division Heads, one Centre Head, and seven Organizational Unit Heads who also report to the DDG-R.

MM systems are always complex and demand special interpersonal skills on the part of every member of the matrix management team for the structure to work well. As IRRI has evolved this structure to meet its specific requirements over the past 3-4 years, it has skilfully avoided the major pitfalls of the MM approach – specifically those having to do with serious, but unintended gaps in responsibilities, and missed opportunities for cooperative activity because of the diffuse nature of the 'ownership' of outputs.

The Panel noted some side effects: the role of the current Programme Leader position is nebulous today and it was noted that since 2002, the DG's Annual Report is structured along Project lines, and not integrated along Programme lines.

Within IRRI at this, time a number of organizational modifications are being considered as the Institute seeks to fine tune the MM approach in the interest of operational efficiencies, simplicity and other reasons. The Panel, for its part, has considered whether the organization is now optimally configured to deliver IRRI's mission. The Panel recognizes the value of having leaders of disciplines – or coherent groups of disciplines – for many purposes. However, it agrees with IRRI that the budgetary and human resources required to deliver the principal outputs should reside with the Project Team Leaders (PTL), being sympathetic to the need to empower those responsible for delivering outputs from multidisciplinary Projects. These PTLs should enjoy a high profile within IRRI and be rewarded accordingly. The Panel therefore supports Management's initiative to devolve responsibility for resources to the Project Leader.

At present, some of the most relevant and thus important outputs for the NARS are delivered through the two Consortia Projects for the favourable and unfavourable environments respectively. Internally, however, the resource requirements for these Consortia Projects are supplied from other Projects – thereby requiring significantly greater attention to coordination and monitoring of results to be sure that the research in these other supporting Projects are optimized for delivery to the NARS. The Panel fully recognizes that this entails cross Project management and extensive interactions and sharing of resources and objectives between Projects, and concomitant demands on the matrix management systems in place.

The Panel **suggests** that the current 'favourable' and 'unfavourable' Programmes should be perceived as two 'flagship' programmes in which the visibility of the Consortia is high from both internal and external perspectives. These Programmes would be led by Programme Leaders who have the responsibility of ensuring that the internal supporting Projects are optimized to deliver the needs of the Consortia, ensuring the efficiency and effectiveness of the Consortia operations with the NARS, and elevating the status of the Consortia.

The third 'flagship' programme would be Programme 1. The Panel believes that the current organizational arrangements that tie its activities into Programmes 2 and 3, while allowing high visibility externally, are appropriate.

The ‘flagship’ concept has a number of advantages: it places accountability for results with one individual, and it is much easier for clients and donors alike to understand the totality of IRRI’s research activity.

The Projects in Programme 4 are heterogeneous and the arguments for the existence of the Programme appear weak. The Panel proposes that Project 10 and 11 activities be folded into other Projects as appropriate and Project 12, Training and Information/knowledge Dissemination, be separately identified as a Unit so that it can enjoy a separate and higher profile status. (See the Recommendation in Chapter 5.)

The proposed changes in Project 10 are more than mere realignments of tasks: what is being proposed here reflects the Panel’s desire to see a more integral role being played by social scientists in developing and prioritizing projects so as to maximize adoption and people’s welfare. The Panel also recognizes that the current level of resources available for social science work may be inadequate, but leaves IRRI Management to work out how much of the greater scope of work will be met by additional resources, and how much by a realignment of personnel within the Social Sciences Division.

In sum, the Panel believes that an organization consisting of three ‘flagship’ Programmes, a highly visible Unit delivering training and information/knowledge and high quality disciplinary-based Divisions should serve IRRI well into the future as it continues to ‘market’ its relevance and compete with other organizations for funding.

7.5 Planning, Priority Setting and Monitoring

7.5.1 The Process – A Description

IRRI’s planning process begins with the development of a Strategic Plan. This plan, that is developed about every 8 years following extensive consultations with IRRI’s partners, scientific staff, donors and CGIAR officials, governments, and farmers, establishes the future direction of the Institute and the proximate resource envelope within which IRRI is expected to operate for the ensuing 10 years. The last plan ‘IRRI Towards 2020’ was initially approved by the Board in 1996; an update was completed in November 2003 just prior to the initial visit by the EPMR Panel.

The Strategic Plan lays out IRRI’s Mission Statement (goals, objectives, strategy and values), the policies that govern its activities (scientific quality, efficiency and equity, collaboration and partnerships and research relevance), and the priorities that guide the institution in terms of the allocation of scarce resources as among rice ecosystems, geographic regions, and between basic and applied research activities.

Annually, Management prepares the rolling Medium Term Plan (MTP) – a Plan covering the institution’s activities for the next three years in the format suggested by the CGIAR System. This Plan, which is currently in preparation for the period 2005-2007, builds upon and updates the strategic plan developed in 1996-97. The MTP takes the strategic plan to the next level of detail and, once endorsed by the Board, is the basic research guideline and priority setting exercise for all activities over the forecast period. Individual programmes, projects and tasks are identified and the resources for each are allocated following an extensive review of alternatives in Network/Consortia meetings, an annual planning meeting, and other processes, including the review of grant proposals by senior Management.

Programme Leaders and Project Leaders are assigned and resources allocated to complete the agreed activities.

As Projects are implemented, the financial systems monitor expenses against an agreed plan and financial reports are generated for use by each level of the management structure. Quality control (research) is exercised by the DDG-R who has responsibility for all four research Programmes and the research support services. The DDG-P is solely responsible for the quality of the remaining support services – Networks, Communications/Publications, Information Technology, Intellectual Property Management, the Library and Visitor/Info Services. The DG issues an Annual Report, by Project, that discusses Project activity, performance to date, and expectations for the future from a more qualitative perspective.

7.5.2 Assessment

As noted above, some **Board members** are concerned that they do not have adequate collaborative input to the development of the Strategic Plan at the level they would like: that the current strategic plan is an update of an older plan and, as such, does not benefit from the *ab initio* thinking that some would like to have seen. This is particularly relevant, they say, at a time when there are competing claims for the research dollar that historically would have gone to IRRI. Furthermore, there is increasing competition in terms of the research itself as between national research organizations, the international organizations such as IRRI, and increasingly, the private sector. This shifting landscape, some Trustees argue, is reason for taking a completely fresh look at IRRI's strategic alternatives – as illustrated by the current discussions on different scenarios of a strategic alliance between IRRI and CIMMYT.

A number of the **scientific staff** would also welcome more extensive debates about IRRI's vision and strategy for the future. Some staff believe that future opportunities for IRRI's participation in the research on rice may well be significantly different from the current approaches reflected in the plans and Projects.

The shift in **funding dynamics** for all the CGIAR Centres is having a profound effect on CGIAR Centre priority setting, and hence on the strategic direction of research. Increasingly, Centres are having to cut their core budgeted research efforts as the proportion of core funded to restricted core funding drops. While the effect of this shift in funding has been rather less for IRRI than for other Centres (IRRI's proportion of unrestricted funding, including 'other' income, stood at 51% of total revenue in 2003 compared to 42% for the system as a whole) nevertheless, the trend is clear, and IRRI's strategic plan must take cognizance of this fact. Some further reduction in this percentage is envisaged in the MTP, however the Panel would have expected that the MTP would explore alternatives depending on the assumptions made about funding trends and levels, and articulate those for the Board's review.

Some of IRRI's **'clients'** also question IRRI's vision and *modus operandi*. In response to the Panel's Questionnaire, respondents documented their mixed reactions to IRRI's current strategy. More than half questioned IRRI's internal ability to prioritize its activities to reflect the client's views. The most responses, however, concerned how they would like to see changes in IRRI's role in rice research overall. Clients questioned what IRRI does and where its comparative advantage lies today; where its efforts should be focused geographically; and the extent to which some of what IRRI now does should be left to other local, equally competent organizations or even contracted out to other institutes that may be better qualified (or have lower costs) to undertake such research efforts.

Taken together, it is clear that IRRI has not yet articulated a strategy that convinces the wide ranging expectations of its client base. This is no easy task in today's research and funding environment. IRRI's Board is charged with the responsibility of developing and monitoring the Institute's strategic direction and much work needs to be done. Mapping the strategic direction of a CGIAR Institute today is not an easy task. Much is changing within the CGIAR System itself: Challenge Programmes are being introduced that potentially could significantly alter the centre of governance in CGIAR science; Centre consolidation is being explored; and closure is being implemented in at least one case.

As it takes the lead in planning, prioritizing and monitoring IRRI's future participation as a key player in the rice research arena, the Board, together with Management, has a critical task ahead. It must oversee the development of a strategy that:

i. reflects the needs of both donors and clients;
ii. is cognizant of the likely availability of scarce resources (in terms of scientific staff and funding);
iii. optimizes the scientific contribution that IRRI is uniquely able to provide that is likely to produce impacts;
iv. clearly demonstrates that it has explored alternatives sufficiently to justify the priorities that underpin the Strategic Plan; and
v. is coordinated with the CGIAR System's new initiatives.

7.6 IRRI's Administrative Support Services

Elsewhere in this report, the research and research support activities are evaluated in detail: in this Chapter the remaining 'service' functions are evaluated. These are Finance (including Treasury), Human Resources and Administration (including Housing, Legal, Materials Management, Physical Plant, and Safety/Security).

7.6.1 Finance

7.6.1.1 Funding: Trends and Implications

IRRI, like other CGIAR Centres, has experienced a decrease in the absolute level of funding over the review period. Total revenue has dropped 15%, from US$37.7 M in 1998 to US$31.9 M in 2003. IRRI's grant income fell by 21%, from US$34.5 M to US$27.1 M, during this same 6-year period. The major contributors to the decrease in donor revenue were Australia, Denmark, Germany, Japan, and the World Bank.

IRRI's total revenues of US$205 M during this 6-year period included an amount totalling US$19.1 M (9%) resulting from:

a) interest income earned on surplus cash balances (US$8.9 M);
b) the net of investment gains (US$0.2 M) and losses (–US$ zero);
c) the net effects of exchange rate gains (US$6.4 M) and losses (US$1.3 M);
d) income from self-sustaining activities (US$2.9 M); and
e) sundry other income (US$2.1 M).

For 2003 specifically, the net impact of these 'other income' items was an increase in revenue of US$4.8 M, representing 18% of IRRI's total grant income for the year. This added revenue represented an effective 42% increase in unrestricted core operating funds for the year – an important revenue contribution.

Contrary to some other CGIAR Centre expectations, IRRI forecasts that donor funding will increase again beginning in 2004, rising to US$33.3 M by 2006 – an increase of 23% over the next four years. Much of this increase is expected to be in restricted core funding and will come primarily from Challenge Programmes.

A summary of IRRI's operating performance over the review and forecast periods is given in Table 7.1 (following page).

In light of the decreased funding over the past five years, IRRI's Board and Management reacted quickly and appropriately – reducing expenditures by 19% over the same period, primarily by making substantial reductions in staffing complements and associated costs. Internationally recruited (scientific) staff levels dropped from 133 to 105 and nationally recruited staffing levels dropped from 982 to 784 during this 5-year period. The gradual shift in the designation of grant monies mirrors a CGIAR systemwide shift from unrestricted core funding to restricted and Challenge Programme funding. In IRRI's case the historical and projected shift is as shown in Table 7.1.

Table 7.1 - IRRI Programme and Resource Highlights, 1998-2006

Centre Revenue (US$ M)	1998 Actual	1999 Actual	2000 Actual	2001 Actual	2002 Actual	2003 Actual	2004 Plan	2005 Forecast	2006 Forecast
Unrestricted Grants	16.8	16.1	16.5	14.1	12.9	11.5	14.3	14.0	14.0
Restricted Grants(incl. attributed and CPs)	17.7	16.4	17.3	15.9	15.6	15.6	16.1	17.3	19.3
Sub total: Grant income	**34.5**	**32.5**	**33.8**	**30**	**28.5**	**27.1**	**30.4**	**31.3**	**33.3**
Earned Income	3.2	2.5	1.6	2.1	4.9	4.8	2.0	1.6	1.6
Total Revenue	**37.7**	**35.0**	**35.4**	**32.1**	**33.4**	**32.0**	**32.4**	**32.9**	**34.9**
Centre Expenditure (US$ M)	**35.0**	**35.1**	**32.6**	**32.6**	**33.6**	**28.7**	**32.4**	**32.9**	**34.9**
Results from Operations (US$ M) -Surplus (Deficit)	**2.7**	**-0.1**	**2.8**	**-0.5**	**-0.2**	**3.3**	**0.0**	**0.0**	**0.0**
Memo items:									
1. Donors grants by region (US$ M)									
Europe	11.3	9.0	10.8	10.0	12.5	13.0	12.8	*	*
Pacific Rim	10.7	11.4	10.5	8.1	4.4	4.7	4.3	*	*
North America	4.7	4.7	4.8	4.5	4.6	4.5	5.9	*	*
Developing Countries	1.6	1.2	1.1	1.1	1.1	1.1	1.2	*	*
International and regional organ.	4.8	4.9	5.4	5.2	4.6	2.7	4.1	*	*
Foundations	0.9	1.1	1.0	0.8	1.1	0.7	0.5	*	*
Challenge Programmes						0.3	1.3	*	*
Non-members/others	0.5	0.2	0.2	0.3	0.2	0.2	0.2	*	*
2. Expenditure by Object									
Personnel	17.1	16.2	14.9	15.7	16.2	12.8	14.6	14.7	15.0
Supplies/services	13.0	14.0	12.8	12.9	12.8	11.0	12.7	13.7	15.2
Travel	2.5	2.4	2.7	1.8	2.5	3.0	3.0	2.4	2.7
Depreciation	2.4	2.5	2.2	2.2	2.1	1.9	2.0	2.0	2.0
3. Staffing									
IRS-directly employed	63	65	63	66	60	61	62	*	*
IRS-seconded	12	10	6	6	6	6	6	*	*
International Research Fellow	11	11	12	9	9	11	11	*	*
Post Doctoral Fellow	31	36	24	18	19	13	14	*	*
Adjunct Scientist	1	1	1	1	1	1	1	*	*
Visiting Research Fellow	4	3	4	7	3	5	5	*	*
Laision Scientist	4	5	5	6	5	4	4	*	*
Collaborationg Scientist	7	9	10	1	7	4	3	*	*
IRS Subtotal	**133**	**140**	**125**	**114**	**110**	**105**	**106**	**106**	**106**
NRS- in Los Banos	860	887	865	870	665	717	737	*	*
NRS-Outreach	122	122	127	131	70	67	65	*	*
NRS Subtotal	**982**	**1009**	**992**	**1001**	**735**	**784**	**789**	**789**	**789**
Total Staff	**1115**	**1149**	**1117**	**1115**	**845**	**889**	**895**	**895**	**895**
4. Consultants	**20**	**19**	**18**	**22**	**7**	**9**			

The **short-term** implications for this shift are significant. First, IRRI will be less able to fund that innovative and early stage science that would typically lead to external funding once the feasibility of the research effort has been demonstrated using core monies. Second, scientists will increasingly be linked to, and paid by, special projects with the concomitant 'costs' of such short-term employment contracts in terms of the calibre and seniority of scientists willing to relocate to Los Baños for the short term, and in terms of the loss of institutional memory.

Table 7.2 – Historical and Projected Funding from Unrestricted to Restricted Funding at IRRI and in the CGIAR

Donor Funding (%)	1998	2003	2006
(a) IRRI			
Unrestricted	53	51	44
Restricted	47	49	56
(b) CGIAR System			
Unrestricted	61	42	n.a.
Restricted	39	58	n.a.

(Note: Earned income in each year is treated as unrestricted core funding)

The **longer term** implications of this shift in funding are yet to be worked out within the CGIAR System collectively and within each Centre individually. For IRRI specifically, three major questions came to mind as the Panel looked ahead 10 years:

1. Will IRRI's research agenda be increasingly driven by donor interest in, and the availability of, project specific funding to undertake research with a shorter term output time horizon than heretofore (including Challenge Programmes)?
2. Might donors increasingly see IRRI as just one of a number of highly qualified research institutions able to carry out the donor's requests? Absent major innovations by the System as a whole, or by its Board, could IRRI inexorably gravitate towards a consulting/service organization where its survival would depend, *inter alia*, on the competitiveness of its cost structure vis-à-vis other (and possibly nationally based) research institutions? and
3. might the CGIAR seek to restructure its Centres radically in ways that would adversely impact IRRI's vision and competencies?

The Panel believes that this type of 'scenario' thinking is a key activity for IRRI's Board. As noted above, this concern also underlies comments by some Trustees that an 'incremental' strategic plan built on past plans and earlier successes is not where IRRI should be placing its planning efforts at this critical time in the Centre's history. The Panel emphasizes once again, that the Board's major task in the next few years will be to provide strategy driven direction in an increasingly fluid funding driven environment. It will not be easy.

Overall, IRRI's financial 'health' is excellent. IRRI's position, using standard comparative ratios, is shown in Table 7.3.

Table 7.3 – IRRI's Financial Health Indicators

	Actuals						Plan
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
1. Short Term Liquidity							
Working capital (days)	239	170	140	102	291	404	404
Current Ratio	1.7	1.5	1.4	1.3	3.3	3.5	3.5
(CGIAR recommended targets are 90 days and a ratio of 1.5 or better, respectively)							
2. Fixed Assets							
Capital expenditures (US$ M)	5.8	1.0	1.5	2.4	1.1	1.8	1.7
Cap Exp/Depreciation (%)	238	40	68	109	54	85	85

These ratios also confirm that IRRI is in excellent shape financially as it enters 2004. The Panel commends Management for its successes in carefully marshalling scarce resources during times of significant change in donor funding patterns and much uncertainty as to the levels of such funding.

7.6.1.2 Funds Management

(a) Current Account Banking Arrangements: Given its substantial cash balances, Management has wisely made a careful determination of the ranking and quality of the commercial depository institutions used by IRRI. Only the largest Tier One banks are used for the majority (in excess of 98%, typically) of these funds. Some (peso-denominated) funds are also held in a Philippine bank.

In October 2002, the Board of Trustees authorized the Director General to designate the officers with authority to sign. This Authority designates any two of seven senior managers to sign checks, drafts or give other orders to the Institute's financial institutions. There is no evidence that the Finance and Audit Committee reviews the creditworthiness of these institutions and the deposit arrangements (for example the 'cash sweeping' arrangements for the various currency depository accounts) on a frequent basis. The External Auditors (EA) had no criticism of these arrangements in their Management Letters over the review period and the Panel found them generally satisfactory except for the above-mentioned need for periodic review of the arrangements by the FAC.

(b) Invested Funds Management: In light of the funding situation at IRRI, the Panel also carefully reviewed the appropriateness of the current Board approved Investment Guidelines. It also assessed the current portfolio in respect of (a) compliance with the guidelines; (b) hedging arrangements against currency fluctuations, interest rate shifts and maintenance of capital; (c) auditing and reporting arrangements; and d) portfolio benchmarking strategies.

The Panel believes the Investment Policy Guidelines are in need of revision. In examining the current portfolio, the Panel noted that loss of capital has occurred on at least one occasion. The Panel also noted that IRRI has US$2 M invested in a US based Healthcare Company basket equity fund managed by Citibank, NY. Such investments, whilst in strict compliance with the current Guidelines[49] nevertheless raise questions as to the appropriateness of the current Guidelines. Furthermore, it is important to have a formal benchmarking strategy in place for a portfolio of this size, both to gauge the performance of the Investment Advisor and to ensure that IRRI is optimizing its portfolio management guidelines over time.

The Panel recommends that IRRI develop updated Investment Portfolio Guidelines that cover the broad spectrum of portfolio management guidelines typically addressed, including maturities; types of instruments; risk assessment, risk management and reporting; benchmarking arrangements; currency hedging arrangements; and the risk and portfolio reporting procedures for the FAC and the Board, for the External and Internal auditors, and for Management.

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[49] This investment was made in April 1999, and matures in May 2004.

Given the number of currencies and funding sources, IRRI's portfolio management task is neither simple nor easily monitored. Advice from a highly qualified investment adviser, one with particular competencies in international investment opportunities and foreign currency hedging arrangements, will almost certainly be required in developing these new guidelines. In carrying out its governance function, IRRI's Board will need to be receiving periodic reports (at least quarterly for the FAC) that clearly document an expert review of the portfolio metrics, the Policy Guidelines, and the quality of the advisers and custodial arrangements used.

7.6.1.3 Financial Controls and Reporting

The 5th EPMR Panel noted that the finance division was "…staffed with dedicated personnel possessing a high level of professional qualifications….they are supported in their efforts by modern computerized systems and have responded to the funding changes that require increasingly stringent identification of costs and their containment." At that time, the 5th EPMR noted that IRRI was "…in the process of installing a new financial management system to run on networked PCs."

In 2003, IRRI substantially completed the installation of the 'eFinancials System' of accounting. In discussions with users, the Panel believes that this new system satisfies user needs in most accounting areas. The staff (accounting and users) appeared to be pleased with the accuracy, content, accessibility and timeliness of the information produced.

At the Project/task level, minor problems result from a need for consolidated reports and more detail. These problems have two causes:

i. User groups did not completely identify their needs when the system was designed; and
ii. The level of detail and report flexibility required to solve the problems will require a more detailed chart of accounts and account numbering system to capture additional information at the transaction level.

The Finance Department is aware of these problems and is seeking alternate solutions with the software vendor.

The new accounting system prepares perpetual inventory reports that could be used more effectively. At present, the report is used annually to test the physical quantities of selected inventory items: auto parts, fuel, maintenance, and household and office supplies. The Panel suggests that partial physical counts of these and other physical items be compared with perpetual inventories throughout the year and any shortages be brought to Management's attention.

The Panel commends IRRI for identifying a responsive accounting system and for installing and operating it in a very competent manner, and notes the high quality of the staff employed in the Finance organization.

7.6.1.4 The Auditing Function

(a) ***External Auditors:*** IRRI's EAs for the past 6 years are SyCip Gorres Velayo & Co. (SGV) – a Philippine firm that is affiliated with the worldwide firm of Arthur

Anderson through 2001, and after that firm's worldwide demise, with Ernst & Young, International.

CGIAR Guidelines suggest that Centres rotate the External Auditors every 5-7 years. IRRI is using SGV for its 2003 audit and an internal study and for its Programme audits. The Board has already approved a re-bidding of the IRRI EA contract for 2004. The Panel emphasizes that the CGIAR Guidelines require that the current firm (SGV) be excluded from the bid process – a guideline that should be followed.

(b) Internal Auditors: The 5th EPMR Panel noted that "…the Internal Audit unit at IRRI has a direct reporting relationship to the Director General and the Audit Committee, it has been ineffective in improving internal controls." The Review went on to recommend that IRRI ensure that the internal audit function "becomes fully effective in improving internal financial and operational controls, by reviewing the current level of skills available within IRRI for the Internal Audit function, deciding which skills it is necessary to have internally and which skills might be outsourced, and implementing the organizational and staffing changes required."

In response, in 1999 IRRI with two other Centres[50] jointly formed a Consortium to employ a centralized internal audit capability headquartered at IRRI. The approach has worked very well. The Panel Consultant read numerous internal audit reports, met with two of the Internal Auditors involved with the preparation of the audits, and spoke with the Director of the CGIAR Internal Auditing Unit.

The quality of the internal audits is excellent, as was Management's responses to the many issues raised by the audits. Further, the selection of audit areas (including reports on the country offices) was excellent and responsive to the Institute's needs.

Two of these reports addressed the specific deficiencies in the management of the human resources function where the recommendations contained therein have been implemented – the acquisition of a computerized HR management function that is just now becoming operational. The Panel suggests that the Internal Audit group again review the operations of the new system several months after the installation is complete.

The Panel noted that several reports had been completed, but not signed off and released, for many months, The Internal Audit Director has assured the Panel that the final reviews and issuance would be done promptly for the uncompleted and future reports.

7.6.2 Administration and Human Resources

The A & HR group oversees all the administrative support services for IRRI except Finance. This includes Food and Housing, HR (three departments), Legal, Materials Management, Physical Plant, Safety and Security, and Transport services.

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[50] Initially, the Internal Audit group comprised the CGIAR, ICLARM, IPGRI, and IRRI.

7.6.2.1 Human Resources

Within this group, the Human Resources Management Team has faced some particular challenges over the review period. A new Director for Administration and Human Resources (DAHR) was appointed in 1999. An upgraded HR management information system has been procured and is currently being implemented and, most importantly, IRRI was forced to undergo a major staff reduction programme – where the total staff complement was reduced by 20%, from 1,115 to 845 by the end of 2002 as donors to the CGIAR System lowered their contributions[51].

Inevitably, such reductions in staffing leave the remaining staff somewhat demoralized, though IRRI Management clearly took great pains to explain the need for the reductions being made. Some IRRI Trustees commented to the Panel that they felt that the reduction was timely, not just to match costs with reduced funding availability, but also since the smaller IRRI was "probably now at about the right total staffing level for what it is doing these days". Financial projections for the period 2004-2006 are predicated on no increases in total staffing through the period.

The HR departments have appropriate staffing policies and procedures in place, or about to be issued. Philippine labour laws are followed in the case of NRS staff, and IRS staffing policies are in line with those at other CGIAR Centres.

One area of concern noted by some IRS and NRS staff is that the current grievance procedures make it difficult, in practice, for a person who is being adversely affected by his/her immediate supervisor to complain outside of the usual line relationship; i.e. through the immediate supervisor. This deficiency in the current procedures could easily be corrected though the appointment of an independent Ombudsperson who would report directly to the Board Chairperson, and thereby bypass the in-house Appeals Committee and Senior Management. The CG-endorsed Model Grievance Procedures used by most Centres are deficient in this respect: indeed the current Model will need to be modified to reflect the provisions of the new governance legislation or CGIAR Centre Boards will be unable to comply with the DFID-requested attestations.

IRRI's gender profile has changed slightly over the review period: the proportion of female staff has increased over the review period from 33% to 36%. To encourage female IRS candidates to apply, IRRI employs spouses where it is feasible to do so.

IRRI conducts a staff appraisal process annually for all staff, and has recently added a new Classification and Evaluation scheme for IRS staff that seeks to address the multiple dimensions of performance inherent in the MM approach. The appraisal process is thorough and quantitative where appropriate.

7.6.2.2 Physical Plant Services and Computer Systems

The Consultant to the Panel toured the facilities at Los Baños and confirmed that IRRI has consistently maintained the plant and equipment to high standards, and that the provisions for capital replacement (at US$10.7 M) appeared adequate. Insurance coverage for all

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[51] This reduction follows an earlier, similarly sized reduction in 1997 when total staff were reduced from 1680 to 1115 by 1998.

facilities is reviewed regularly – though the costs of actually replicating the genetic materials stored in the International Rice Genebank facility in the event of a loss are not covered – and possibly could not be covered at a reasonable cost. It is noted, however, that some 90% of the accessions are backed up at a facility located in Fort Collins, Colorado.

The Panel noted that adequate computing equipment redundancy, and on-site, and off-site data backup capabilities are in place, and commends IRRI for the redundancy capabilities that have been designed into the overall system. The entire campus has been retrofitted with a fiber-optic data and communications network and is well regarded by staff.

7.6.2.3 Space Planning and Utilization

IRRI has a campus like arrangement for most of its IRS staff and operates a guesthouse for visitors. Staff, and most spouses are content with the housing arrangements, The Panel was very impressed with the facilities.

IRRI's Headquarters facilities, including some of its research fields, are located within the boundaries of the campus of the University of the Philippines, Los Baños (UPLB) under an Operating Agreement that was recently renewed for another 25 years at nominal cost. The current facilities – built to support a total workforce of some 1,600 staff and field labourers, are not fully utilized at the current staffing level of 895. IRRI has arranged to rent some excess space to other users where this is consistent with the Agreement under which IRRI operates, and some space has been utilized for improved staff amenities.

7.6.2.4 Materials Management

As is often the case in CGIAR Centres, this area typically is where the loss of portable equipment, fuel and motor vehicle parts and supplies occurs most often. The Panel has the impression that IRRI's loss experience in this area is probably less severe than at other CGIAR Centres, however, and the overall losses are small. The Internal Audit function has focused attention on the systems and the 'checks and balances' in place and there appears to be suitable controls in place. The Panel has commented elsewhere in the Report on the need to improve perpetual inventory checking routines.

7.6.2.5 Safety and Security

IRRI maintains its own fire and police units – both of which work closely with their counterparts on the UPLB campus.

General security arrangements have been generally adequate in the past, even though there have been several serious incidents, including a murder on the field site (not an IRRI staff member), several car-jacking incidents and a grenade throwing incident at a senior staff member's home. IRRI recently commissioned an extensive study of its security arrangements and, in light of the study findings, expects to make a number of improvements including controlled access to many sensitive locations, closed circuit TV monitoring installations and other arrangements as necessary. The Panel was impressed with the quality of the recommendations.

CHAPTER 8 - THE WAY FORWARD

8.1 The Challenges Facing IRRI

We are now at a new and extraordinary time in the history of the application of science to aid poverty alleviation via research on rice culture. If one were to describe the ideal scenario about what would be required to launch the most penetrating research programme for agricultural research on rice it would include:

- skilled teams of social scientists, breeders, physiologists, pathologists, geneticists, biochemists, agronomists, hydrologists and systems modelers in institutions with critical mass and in mature networks to provide, via collaborations, understanding of needs, and the means of delivering and evaluating technologies on farms in a diversity of environments;
- a huge, well curated collection of wild, land race and elite germplasm;
- an experienced consortium of crop scientists that can evaluate germplasm and technologies in many different environments;
- a complete reference sequence of the DNA of all the rice chromosomes;
- a global framework of scientists eager to use their skills to enhance agricultural applications and consumer preferences;
- other scientists, throughout the world, eager to know the results of the research and to use it as a model for their work on other plants and crop species;
- ways of disseminating the information globally to almost all who can use the information;
- many organizations and governments willing to fund the research; and
- a cadre of young scientists inspired to study the crop and its applications for a variety of purposes and to build their careers on making discoveries.

This is what is now or could be available for rice, as never before, and it prompts and facilitates an evolution in rice research and consequently for IRRI. The Panel sees that in addition to the gradual progress that has been occurring over the years there have been some innovations over the past five years that have significantly altered the vision. The opportunity is extraordinary, exciting and should be grasped.

In relation to the requirements for the ideal scenario listed above, skilled teams of specialists do exist both at IRRI and in NARS and ARIs that provide critical mass and mature networks. IRRI is the organization with the best collection of curated germplasm and linked with experienced Consortia of crop scientists ready to exchange and evaluate germplasm. China, USA, EU, India, Japan, and others are spending relatively large sums of money to understand the biodiversity in rice and the function of genes in its chromosomes via association and linkage genetics using molecular biology. Rice is now prominent as a model plant on which to conduct research, and students all over the world are being inspired and funded to explore some of the basics of developmental biology in different environments using rice. IRRI, CIAT and WARDA and all the NARS in Asia and elsewhere have multidisciplinary teams, many of which are networked and working efficiently and collaboratively. Telecommunication developments now enable global dissemination of information. Although traditional donors have been less willing to fund rice based research compared with two and three decades ago, the new rice research is receiving funding from developed country, national science granting bodies.

All this has not come about by accident. It has come from sustained investments over decades, hard work and inspired leadership in many institutions but drawn together by a common science base. It is, therefore, more timely than ever for IRRI and the CGIAR to review how their specific missions to reduce poverty in the world can be achieved by inspiring and leveraging this extraordinary situation. IRRI and the CGIAR are extremely well placed to do this.

In reflecting on the potential of any scenario in research it is, of course, often impossible to anticipate the effects of major discoveries or changes in political and other factors. However, such factors will emerge over the next ten years. The discoveries over the past twenty years, which have introduced major changes in the way plant science relevant to IRRI is done, have not come from discoveries within plant science itself. The advances in biotechnology are all predicated on research discoveries from bacterial genetics and the entrepreneurial, venture backed biotechnology industries. The technology developments in sequencing the rice genome came from investments in electronics, chemistry and bioinformatics, driven by the financial base of medical research. In NRM, the transforming technologies have come from developments in remote sensing, applied mathematics and satellite technology developed for space research and defence industries, which have provided the tools for GPS (global positioning systems) and GIS (geographic information systems). One of the largest impacts has come from the development of high speed computers and the web, that have added much to the pace of research, global competitiveness and speed of dissemination. Because of this, it is always essential that IRRI and the CGIAR be alert to the breakthroughs that will change the prospective for improvement in rice agriculture. Failure to recognize these can greatly affect the comparative advantage and marginalize any strategy.

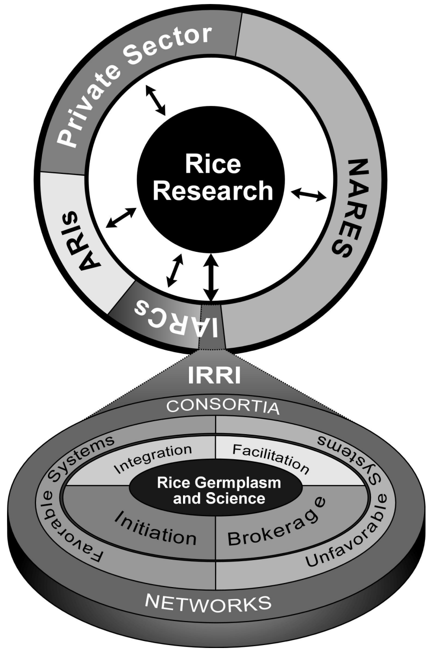
In painting an optimistic picture of the brave new world opened up by science, in particular by molecular genetics, the Panel would be remiss if it does not point out some downside to the story. What used to be largely open science has now many fences created by intellectual property rights of the private sector, and by the various new concepts introduced in the Convention on Biological Diversity (see Chapter 1). When transgenic technology creates new products, its application and adoption are restricted by biosafety concerns and regulations which can make costs high, even before the value of the gene is known. No doubt, governments introduce property rights and biosafety regulations for sound reasons, but for an institution like IRRI they are a problem that has to be tackled.

8.2 IRRI's Responses to the Challenges

8.2.1 IRRI Among Other Actors in Rice Research

Conceptualizing the new environment with multiple actors, and IRRI's role within it, would yield something like the top of Figure 8.1. The actors involved in rice research are many. There are NARS, including the extension, NGOs, the IARCs, the ARIs, and increasingly the private sector. IRRI is only one among these, even though it is the only one (other than WARDA) that works exclusively on rice. IRRI has to position itself among these other institutions, which could possibly compete with it if IRRI plays its cards wrongly, but may also cooperate to enhance IRRI's output if IRRI proceeds sensitively.

Figure 8.1 – IRRI's Role within the New Rice Environment



What are IRRI's core assets and competencies which give IRRI a comparative advantage amongst these different actors? That core (also displayed in the bottom half of Figure 8.1) is the germplasm collection that IRRI holds, on trust, for the world. IRRI has the best curated collection of rice germplasm, including wild, land races and elite lines, the abilities to carry out field trials and the like to improve rice for various uses in diverse environments and, above all, a substantial and recognized history in multidisciplinary rice research and its use for alleviating poverty. It is located in Asia and IRRI staff can travel anywhere. It also has outreach staff and others who are based in carefully selected areas in Asia, and has a distinguished record in training people.

Associated with the germplasm is a corps of scientists, which IRRI has to ensure are of the highest calibre. The Panel finds that it has indeed little difficulty in recruiting such high calibre scientists, capable of scanning the latest developments in science and applying them to the problems of rice, and sometimes advancing the frontiers of science. They have credibility among the scientists of other institutions.

For it to be effective, IRRI has to leverage that core into a working model that will yield results by which it is to be judged. Since IRRI's mission is to alleviate poverty, it has to have the means of delivering the results of its labours to have that impact, primarily through increasing farm productivity in two ecosystems labelled 'favourable' and 'unfavourable'. In doing so, it not only uses its own resources, but pulls in resources from the other actors shown at the top of Figure 8.1, using four methods:

- it *facilitates* interaction among actors, for example by making it easier for actors to exchange germplasm;
- it *integrates* knowledge of rice science, and makes it available to actors;
- it *brokers* relationships between the actors; for example, its scientists may bring together and help set up a collaboration between an ARI scientist and a NARS scientist; and

- it *initiates* projects on rice science that would advance the science, as well as help it to fulfil its mission of poverty alleviation.

Finally, when applicable research results do appear, it has the mechanism to disseminate them through its consortia and networks. In addition, IRRI has a major training dimension.

This then is the milieu and the operational mode of IRRI. In this landscape, IRRI will not always be the party to find the answers, but will capitalize on its unusual institutional character to bring actors on the top of Figure 8.1 together. It can do this effectively, for aside from its command of rice science, it is – uniquely among the institutions conducting rice research in Asia – non-profit, apolitical and international. This status combines to give a special position of trust. The value of these should not be underestimated in a world in which nations seek to develop their economies competitively, and where there is increasing likelihood that what used to be considered international public goods (e.g. germplasm) will no longer be freely shared.

The comparative advantage that it has in this community of institutions working on rice science can be sustained if it demonstrates that it is:

(a) the highly respected source of knowledge for rice based systems and improved germplasm of proven value for defined environments and for human health, working with NARS and NGOs to make improvements locally in the quality of life for rice consumers anywhere and everywhere. IRRI would play a large role in ensuring the sharing of reliable knowledge, innovative technologies and communication networks between countries; and

(b) an international leader supplying information to all on rice germplasm, genetics and genomics and its intrinsic attributes for farmer, environment, and consumer, etc. via linked web based systems so that every scientist, graduate student, technician. etc. for the years to come, all over the world, will be inspired and empowered to contribute to rice knowledge using whatever funds are available, or can be raised, and the facilities of others.

It is often queried whether IRRI should position and equip itself to be an upstream or development Centre or a mix given the changing externalities and needs. This question seems wrongly conceived. IRRI does and should use and develop state-of-the-art upstream information and technology and make sure its carefully selected products and services are delivered downstream as efficiently and effectively as possible. At all steps it should collaborate with whoever, upstream or downstream, has the skills and comparative advantages to contribute to delivery of the selected products/services. IRRI should therefore be neither an upstream organization nor a development Institute. Advanced rice research is now being conducted at many top class institutions in all continents and IRRI's major role should be to coordinate all the relevant information and see that it is made available to empower all via web based systems. There are hundreds of development institutions and IRRI would add little to these without its up-to-date links to the science base of rice. This is, in fact, the brokering function.

All these advantages taken together are likely to stay relevant over the coming decade if IRRI continues to receive strong support and it has the right vision, strategy and strong management. No other single rice based research organization has this complement of assets or overall strength. However, this could change and probably will; some of the richer Asian countries are seeking to become much more self-sufficient in rice agricultural research. On the other hand, they may make the transition to becoming influential donors within their own region. With web-based information systems and the much higher global interest in rice research, skills, experience and people are now very mobile.

8.2.2 Fulfilling IRRI's Mission

Provided that IRRI remains vigilant in keeping its relevance and comparative advantage over the coming years, it is well positioned to sustain its two principal mandates:

- poverty alleviation through rice- based research; and
- conservation and curation of rice germplasm and dissemination of the associated information to the world.

The Panel's vision for IRRI and its role in rice research assume no major restructuring of the CGIAR or severe funding changes. Our views are based on a US$30-35 million Centre, but one that is highly capable and competitive in the struggle for funds to alleviate poverty through the application of science. Resource constraint will therefore always be a fact of life, and perhaps this is as it should be, if IRRI is to be a tightly run organization.

8.2.2.1 Poverty Alleviation

If the resource constraint is to be respected, IRRI needs to be careful that its resource allocation ensures cost-effective use of research funds to reduce poverty. What then should be the balance between the resources devoted to the two sorts of environments, favourable and fragile, recognizing of course that the two overlap and that breakthroughs for one environment will often be applicable or relevant in the other?

In attempting to answer this difficult question, the Panel starts with two objectives and one constraint. The first objective is for IRRI to contribute to the alleviation of poverty, and for IRRI the central concern would have to be Asian poverty which still accounts for the greater part of world poverty. The second is, in view of the looming shortage of water, for IRRI to ensure that rice production minimizes the use of water as far as possible. The constraint is that IRRI is a producer of rice production technology, and therefore the relative emphasis should recognize the limits on how much such technology can contribute towards meeting the two objectives.

The Panel has examined the current levels of resources in the two ecosystems, has considered the needs of the different groups of the poor, the ability of technology to solve their problems, taken guesses on what the probabilities of success in the various lines of research, and concludes that the present allocation of resources between the Favourable and the Fragile Ecosystem Programmes is about right, although there is room for adjustments within the latter, with more going to the rainfed lowlands and less to upland, because of the greater probability of success in the one over the other.

The Panel has arrived at this judgement with large doses of subjective considerations. While subjective judgements are unavoidable in such exercises, it would be quite helpful for IRRI's planning and for its relations with donors if the assumptions and the subjective judgements underlying the exercise above were made explicit and quantified as much as possible.

8.2.2.2 Conservation and Analyses of Germplasm for the Rice World

The second thrust of IRRI is conservation and curation of rice germplasm with dissemination of the associated information. It is summarized in Chapter 2. This thrust stems from its current responsibilities from housing, on trust, the International Rice Genebank Collection. This is one of the most exciting and important activities worldwide in crop biology in the next ten years. Answers to many vital applied and fundamental questions that are buried in this germplasm are being vigorously addressed in the US, Japan, China and Europe. Most of the information is being published. The funding in these countries seems likely to continue. NSF, for example, is committed to characterizing many features of rice germplasm over the coming years. The challenge involves generating the knowledge to link chromosome segments and genes to traits in the field. It involves high throughput molecular assays on large numbers of samples, on the one hand, and careful field measurements of plant traits on the other. IRRI should do all it can to empower all the other players in the world to get these tasks done as rapidly as possible in a structured way, using the resources of others, and to disseminate the information to all via web-based systems. IRRI can facilitate and stimulate this because it has the germplasm and, with INGER and others, can help make sure it is evaluated to learn the chromosome segments that contribute to important traits. This knowledge will guide breeding in the future.

8.2.3 Responding to the Intellectual Property and Regulatory Issues

IRRI needs to operate with a strong IP strategy, despite its commitment to providing germplasm freely to all. Behind the issue is whether the poor are going to be served by IRRI with top quality proven science and discoveries, patented or not, or only unprotected, probably less proven and inferior technology that takes longer to develop. The answer seems clear: if IRRI does not use the most useful technology, patented or not, it will become less relevant to both donors and client countries and will have increasing difficulty in sustaining top scientists. It will risk wasting resources trying to find alternative solutions. It is therefore inevitable that IRRI will need to seek more licenses to needed technologies, providing that they do not undermine its purpose and do not compromise the benefits.

In recognition of all these new challenges, IRRI has produced a Board approved policy on germplasm management, engineering and software discoveries and IPR in general. This necessarily embodies links with the private sector. The EPMR Panel congratulates IRRI on the initiatives it has taken and agrees with the principles set out within it. This policy attempts to sustain as many as possible of IRRI’s products as international public goods but IRRI also recognizes that if it is to serve the poor well it must not automatically exclude the use of germplasm and technologies that carry IPR. The policies are carefully blended to allow this. While the policy is well thought out, the main challenge is in fulfilling its principles on a case by case basis, in-house and with its clients, and effectively maintaining IRRI’s mission for the poor.

The current complexities of the regulations surrounding the release of transgenic germplasm into agriculture and food chains are well known. At the same time, IRRI needs to continue to respond to the NARS wishing to take advantage of these breakthroughs. Fortunately, the private and the public sectors in developed and developing countries are screening large number of transgenes and moving valuable ones through field trials towards products. Thus, IRRI can afford to monitor these advances and only commit itself to develop highly selected, NARS approved transgenic varieties when the value, biosafety and IP license issues can be clarified. Consequently, IRRI should not put a high proportion of its resources into this area ahead of progress elsewhere. This is one case where IRRI might usefully position itself as a fast follower with or behind another Asian country.

There is the additional very important issue of whether IRRI should release transgenics at all because of the perceived risk of genetically contaminating other strains, especially wild strains, with transgenes. Are there risks that would create any liabilities, scientific or legal, for IRRI? To conduct field trial of any transgenic, permission from the government of the country in which the trial is to take place is necessary. To the extent that regulations are in place, IRRI should ensure strict compliance among its own scientists and, if IRRI finances the operation, of its partners' scientists as well. One area for which IRRI has responsibility covers risks to IRGC lines. The Panel strongly suggests that IRRI does not plant, harvest seed, store or transport any transgenics in such a way that they could contaminate the IRGC lines. Any such contamination occurring due to IRRI or a partner's fault would greatly undermine IRRI's reputation. This is a serious issue that should be managed very carefully.

In summary, IRRI Management and Board must pay the highest attention to the evolution of the transgene and IPR landscape internationally, and scrutinize every item adopted into its research Programmes for ownership and IPR issues. IRRI should make sure that its internal IP Management Unit functions efficiently and effectively and that its standards for handling IPR are impeccable. Internal audits on technology in use should be routine and results reported to the Board. A high emphasis on training of these issues must be maintained in-house and with all other stakeholders. Management of IP matters is continuous, as for example, if genes not known to carry patents on an initial analysis have patents granted later on, IRRI may not be free to release products it has been developing using these genes. In such cases, licenses must be gained by IRRI and client countries or the project abandoned. If IRRI seeks a license it must do its best to ensure that its client countries will be legally able to receive and use the products, recognizing that this may be in many years time. Mistakes will be costly. They will waste resources, undermine credibility of client countries and donors in IRRI and the CGIAR as a cost-effective, realistic way of bringing the best technology to benefit the poor.

If all this sounds ominous, it should be noted that the problems exist because a new extraordinary knowledge base has opened up for IRRI to exploit for the poor, and many of the leading industries are making discoveries that can be channelled by IRRI for the benefit of the poor with perhaps spectacular gains as the decade goes by.

8.2.4 How Should IRRI Organize Its Research to Deliver Its Mission?

The research to address the favourable and the fragile environments is currently carried out in two Programmes even though it is recognized that they are far from mutually exclusive categories. Nevertheless, the two Programmes called 2 and 3 should remain. However it should be strengthened in a number of ways.

The Panel recommends that Programmes 2 and 3 become the flagships of IRRI's research effort, with strong and articulate Leaders, who should prioritize and

implement integrated research within their assigned ecosystems. They will be IRRI's representatives in the Programmes' research consortia and will be the spokespersons for their respective Programmes. The Leaders have the following tasks:

i. **When setting priorities they should evaluate alternative approaches to alleviating the poverty problems in their ecosystems, and recommend changes to project structure as needed.**
ii. **In implementing the research they should control the GOC and FTE inputs, and thus may negotiate for the human resources from all the Divisions as needed.**
iii. **At particular milestones during or at the close of their research, they should sponsor studies of the impact of their work.**

The third major area underpinning the research in Programmes 2 and 3 is functional genomics and germplasm analysis in Programme 1. This has the underpinning role for internal research and also a highly visible role in germplasm provision and genetic analysis to the global rice community. It is appropriate that this exists as a Programme to provide this status, but its leader currently spending most of his time on the work of Programme 2 should ensure that its internal underpinning role is not compromised.

The Panel considers that these three Programmes and their outputs should be presented and perceived as the flagships of IRRI. We suggest that the current Programme 4, based around the social sciences and on information dissemination, should be disbanded. Some of the social sciences work should be incorporated into Programmes 2 and 3 to ensure that all major projects have inputs from the social scientists, from inception to delivery and adoption. Such an arrangement should make transparent their role in alleviating poverty. The training and information dissemination component of the current Programme 4 should also have a new status because of its extreme importance and the opportunities in the new era of information technology.

The three Programme Leaders should carry the responsibilities not only to manage the integration of the work needed to deliver the outputs but also to ensure that the Programme priorities and outputs are closely coupled to partner needs. The two principal Consortia, currently Projects 6 and 9, are capable of being elevated to take on this role. These should form the delivery vehicles of Programmes 2 and 3.

With these three Programmes what should be the balance between them? This question has no simple answer because the funds going to each are being influenced increasingly by special projects and the Challenge Programmes. The Panel is making its judgements on a current picture and that which seems likely to emerge in future years.

The resources should of course follow the priorities that emerge from assessments of all the variables that should influence budget allocations, including FTEs. The Panel has already provided some tentative answers as to the factors that influence the relative needs between Programmes 2 and 3. As for Programme 1, the Panel merely observes that for the next five to ten years, IRRI may have a degree of freedom in that there are many advanced research institutions eager to do work in rice. It needs to provide a base of scientific competence on which IRRI resources will have to be expended. Provided this is done, these institutions would choose to work with IRRI, and even on problems of concern to IRRI.

8.2.5 Should IRRI Work More on Africa?

IRRI, with its policy to make germplasm and knowledge available to all as far as this is possible, serves rich and poor, for-profit and non-profit alike. IRRI fulfils its mission of alleviating hunger and poverty by stimulation and empowering of scientists to deliver products and systems that result in better and more food and improved economies of the families, regions and or countries. The information and training made available by IRRI is not all rice-specific even though it is rice-centric. Thus it should be recognized that many of IRRI's future outputs are relatively neutral with respect to these questions.

The information thus collated and disseminated by IRRI will be available to all and thus is continent neutral. This means that IRRI would serve the globe in germplasm, genetic and trait information. The value of this in Latin America and Africa should not be underestimated. Teaching and training could also be continent neutral. It seems to the Panel that the specific regional targets that IRRI chooses to address with its selected partners should continue to be Asia based given the existing needs, the current good working relationships with Asian NARS, NGOs and the CIAT programme in Latin America. Its relationship with WARDA has, however, been fraught with tension, ranging from hostile to merely indifferent, although recently the relationship has become cordial again, and it is time for IRRI to reconsider the case for Africa, which is also what its Board has been doing.

The case for going into Africa rests almost entirely on the number of poor there, which is second to South Asia among the major regions of the world. But is rice research from IRRI the appropriate means to tackle that problem, given the fact that rice is merely one of the many food crops grown and consumed in Africa? Besides, whatever rice growing there is, is grown mostly in upland conditions in fields with mixed farming. IRRI's work in areas with similar ecosystems in Asia has not been productive. There are irrigated areas in parts of West Africa, and rainfed lowland paddies in Madagascar where IRRI could make a useful contribution, but these produce somewhat less than 5 million tonnes currently, a little above Nepal.

The Panel suggests that IRRI should evaluate carefully the cost-effectiveness of any expansion into Africa. Should it decide to go ahead, it should do so in tandem with partners, for they are needed to work in the peculiarly difficult agronomic conditions of that continent. For West Africa, IRRI cannot proceed without WARDA. The Panel suggests that as a starting point, potential partners be invited to Los Banõs, where they can be shown what IRRI has to offer, so that they can frame their requests to IRRI with its advantages in mind.

8.2.6 Governance and Management

As IRRI looks to position itself within this exciting milieu of rice research worldwide, the nimbleness of its internal structure and processes must match the task ahead.

IRRI's Board of Trustees will need to be thoroughly engaged in planning and monitoring the direction that IRRI will pursue into the future. The stakes cannot be higher; crafting a vision and accompanying growth strategy for the years ahead will ensure that the poor in every country will benefit. Getting IRRI's strategy wrong will sideline IRRI as a centre of excellence and relevance. The poor will be the losers, since no other institution has the unique combination of being apolitical, the sole curator of rice knowledge and essentially unlimited access to every rice growing country.

For its part, IRRI Management has the responsibility of keeping IRRI at the forefront of science and relevance. Management has shown remarkable leadership in placing IRRI where it is today, and the task ahead will be no less challenging. This EPMR has made recommendations in respect of vision and strategy and also in respect of programme structure and content that pertain to perhaps the next 5 years. No one knows today how IRRI should best position itself 10 years from now to take advantage of the emerging science and thereby best help the poor. What we do know is that Management must remain alert to an ever changing environment and adopt those strategies and processes that best enable it to carry out its mission. It will be a challenging task.

8.2.7 Financial Resources

Donors overall have reduced their contributions to IRRI significantly over the past few years. Our questionnaire showed that further declines are likely over the coming decade with the status quo. It is vital that sufficient resources are available to sustain the institution at a top class level. Unless this happens, IRRI will simply become increasingly irrelevant, the quality of staff retained will decline, it will not be attractive to new blood and its stature relative to ever increasing international standards will fall below the critical level. This must not be allowed to happen. Given the exciting work that the Panel sees in IRRI, donor reluctance is difficult to understand. The Panel suspects that part of the problem may lie in the articulation of the scope and thrust of IRRI's work, and that the poor articulation may arise from the unclear vision that IRRI has of its own potential, an issue which has been alluded to earlier. The Panel hopes that, with a clearer articulation from IRRI, the donors will collectively understand and work in concert with Board and Management to ensure that sufficient resources are sustained to keep the institution at a top class level.

The CGIAR has launched Challenge Programmes involving many institutions including CGIAR Centres, universities and research institutions in all continents. The Panel welcomes this move in the interests of harnessing the best minds to address the need of the poor. As a by-product, these bring in funds from some other sources into the CGIAR and IRRI's mission. However, it has reduced core funds of IRRI, with decreasing scientific and financial flexibility. This approach will be well justified if the outputs that benefit the poor and IRRI's mission are greatly enhanced. However, the CGIAR should monitor these carefully and also the Institute's abilities to deliver on other missions and sustain their overall quality. It appears that increasingly, as elsewhere in the world, IRRI scientists will need to devote much time to seeking funds from diverse sources to progress their careers and enhance the standing of the institutions. It is to be hoped that by more and higher quality collaborations, IRRI scientists can benefit from working with and learning from the best in the world and bringing new skills and information into IRRI.

Challenge Programmes and other collaborations result in IRRI's projects being managed from outside. This can create additional internal tensions and can result in scientists becoming less focused on IRRI. However, this should not be a problem if the project is clearly within IRRI's specific plan and focus.

8.3 Conclusion

IRRI's vision for the future must be one that clearly focuses attention on the plight of the world's poor, that emboldens donors to fund increasingly complex science, some with longer term and less clear outcomes, and that energizes the institution to achieve excellence in an uncertain environment.

The Panel suggests that a statement along the following lines may be a starting point for this important debate about IRRI's future:

IRRI will continue to be the politically neutral worldwide curator of knowledge on rice. Its research activities and coordinating role will focus on using the knowledge base to design high-yielding, high quality, sustainable plant varieties and concomitant farming systems that ultimately alleviate hunger and poverty – primarily in those countries where IRRI has a recognized opportunity to add value. It will do this through local NARS, Consortia arrangements, and/or in cooperation with the private sector – indeed wherever the comparative advantage lies at the time.

To maintain its position at the forefront of rice science, IRRI will be a well respected, sought after partner in the scientific community – looking for those intersections where developing sciences may be useful in furthering IRRI's vision for the poor.

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